SCIENCE

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MEDICINE AND SOCIOLOGY[1]

IT is a pleasure to have this opportunity to be with you at your commencement exercises. Rush has attracted many Wisconsin graduates medically inclined. Not only in the present graduating class but also among the members of your faculty I greet not a few Wisconsin men. Furthermore, the University of Chicago, with which Rush is officially affiliated, has a course in the premedical and medical sciences similar in ideals to the one we have at Wisconsin. In the premedical course at Chicago in addition to physics, chemistry, biology and a modern language some work is required in social science. Work of this kind is advised but not required at Wisconsin, but I am not sure but that it should be required there. There is ever greater need for sociology in medicine.

On the one hand, medical problems are at bottom social problems and are to be wisely solved only by those who have some knowledge of social science. On the other hand, the increasing complexity of the social organization brought about by the introduction of machinery and of rapid means of transportation of people, materials and news, the urbanization of the population and industrial concentration, have developed social problems which demand above all else the intelligence of men broadly trained in medicine. The triumphs of civilization are due to organization, to the subordination of individual whims to broad social aims. Its failings, on the other hand, are in large part due to the too constant appeal to selfish personal in-

[1] Address delivered at the commencement exercises of Rush Medical College, June, 1911.

terests as an inducement to social effort. Much that is weak and inefficient in the treatment of disease by physicians is due to a too narrow preliminary training, to a too restricted attitude, to a selfish, competitive, unprogressive individualism, archaic and out of place in modern highly organized society. Many of the worst evils of our present-day civilization, dirt, ill health, despondency, pauperism and crime, are in large part due to the failure on the part of the majority of those trained in medicine to act as leaders and public educators. Health of body and of mind should be recognized as of first importance to the community. "They have been so recognized, so far as they have been understood," says Havelock Ellis, "in every great period of civilization of which we have much knowledge, as Roman and Moorish ruins alone suffice to testify. That they are not so recognized to-day is the chief element of rottenness in our civilization. We postpone laying the foundations of our social structure in order to elaborate its pinnacles. We have not yet learned that a great civilization is ill built up on the bodies of men and women enfeebled and distorted by overwork, filth and disease" ("The Naturalization of Health," 1892).

The marvelous advance in industrial productivity characteristic of the past century is due, on the one hand, to the ideal of learning all that is possible about nature by observation and experiment, in a word to scientific research, and, on the other hand, to the organized application of this knowledge to human needs. It seems not improbable that during the coming century an equally earnest effort will be made to learn the truth about mankind, by observation and experiment, in order that the application of knowledge to human needs may be made more efficient. Medicine as a science occupies a unique position in that, on the one hand, it is closely bound up with the physical sciences on which industrial productivity depends, with physics, chemistry and biology, while, on the other hand, it deals directly with people in their social relations and is therefore intimately related to sociology. This latter relation has not been sufficiently recognized hitherto by either medical men or sociologists. With the application of a scientific sociology to the needs of mankind the importance of medical science will come more and more to the fore.

About fifty years ago a witty Englishman said that the ancients had tried to make of medicine a science and had failed, the moderns had made of it a trade and had succeeded. There is truth in the statement. The medicine of the ancients was rather an art than a science. Empirical practise was ahead of the theories used to explain the nature of disease and its treatment. Medicine is still too frequently looked at from the standpoint of a trade, but since the Englishman gave his cynical opinion medicine has progressed as a science more than in all the centuries before.

In the development of medicine four stages may be recognized, a demonic, a hygienic, a physiologic and an etiologic.

In demonic medicine disease is looked upon as an evil spirit which has taken possession of the body and which may be scared out by elaborate ceremonies usually accompanied by noise and supposedly fearful looking objects. This type of medicine is found in practically all savage tribes and wide-spread even in semi-civilized countries like China and India and is not unknown in a less crude form in modern America.

In hygienic medicine disease is looked upon as an abnormal functioning of the body which can in large part be over-

come by methods useful in keeping the body in healthful activity, by regulation of the diet, sleep, air, bathing, exercise and mental recreation. This type of medicine was brought to a high stage of development by the Greeks, among whom personal hygiene was practised to a degree of perfection which it has never elsewhere reached. To Hippocrates are ascribed the works in which the hygienic medicine of the Greeks is summarized. It has formed the basis of much of the best medical practise ever since. If, however, as some historians believe, the decline of Greece was due in large part to malaria, the Greeks in the end served to illustrate the inadequacy of merely hygienic medicine.

Physiologic medicine is based upon centuries of study of the structure and functions of the body in health and disease. It began among the Greeks soon after the time of Hippocrates and reached its highest development during the nineteenth century. It seeks to determine accurately just what structural or functional disturbances underlie the symptoms of a given disease, to what extent the disturbances are beneficial and to what extent detrimental, and what may be done to allay the detrimental and excite the beneficial disturbances. It has given rise to refined methods of diagnosis so that lesions of the heart, the lungs, the kidneys and other vital organs may be determined with considerable accuracy, and steps taken so far as possible to overcome these defects by use of drugs, operations or carefully regulated habits of living. It has shown that not all symptoms of disease are signs of an injured mechanism, but rather may frequently be signs of a vigorous healthy fight against invasion. Thus fevers are frequently, if not always, accompanied by the production of living cells or of chemical substances which attack invading disease germs. The fight may be lost and the mechanism may be permanently damaged, but on the other hand the fight may be won. That a fight won against a mild invader may enable the body to resist a stronger one was shown in the latter part of the eighteenth century by Jenner, who discovered that inoculation with cowpox will protect against smallpox. This great discovery of vaccination soon proved a blessing to mankind, but nearly a century passed before scientific knowledge and methods became sufficiently developed to give us the Pasteur treatment for rabies, the Behring serum treatment for diphtheria, and the opsonic therapy of Wright, all based upon the idea either of stimulating the normal power of the body to resist disease or of stimulating an animal to resist disease and then utilizing its resistance products by injecting them into the human body. These biological methods of treating infectious or contagious diseases are to be contrasted with the merely chemical methods of which until recently but two were known to be specific: mercury in syphilis, derived from the Arabian use of the drug in cutaneous affections, and quinine in malaria, derived in the eighteenth century from the use by natives of Peru of Peruvian bark to cure fevers. Recently the genius of Ehrlich has enabled him to add at least one new specific drug, another cure for syphilis, and to open a new field for work.

In another direction physiological research has shown that when an organ whose secretions are needed for normal activities is deficient its place may sometimes be taken by extracts from organs of the lower mammals. The use of thyroid extract in cretinism and myxœdema is one of the greatest gifts of physiology to medicine. Nothing is more astonishing than the development of a cretin, otherwise des-

tined to a dwarfish, toad-like existence, into a nearly or quite normal individual when fed on the extract of thyroid glands of the sheep.

Modern surgery is an outgrowth of physiological medicine, although many of its triumphs are due to asepsis, and this in turn is a product of the stage of medicine next to be considered, the etiologic.

Etiologic medicine seeks to determine the causes of disease and to deal directly with these. It is a direct outgrowth of physiologic medicine and has really been the aim of the foremost students of the physiology of disease. While the causes of some diseases have been fairly well understood for many years, etiologic medicine was first really placed on a firm basis by the genius of Pasteur and Koch about fifty years ago. In infectious and contagious diseases the specific organisms and their mode of transmission have been discovered in a large number of cases, and in others much has been learned even where the specific organism has not yet been discovered. Thus one species of mosquito is known to transmit malaria, another to transmit yellow fever. The malarial organism is known, that of yellow fever is not. Malaria can be fairly successfully treated with quinine. There is no specific for yellow fever. Both diseases can be abolished by getting rid of the mosquito. Typhoid fever, for which there is no specific, can be gotten rid of by guarding water and food supplies and for a time, at least, guarding the public against typhoid carriers, people who harbor the germ without themselves being sick. Such carriers, however, would probably not exist where the water and food supplies have been kept pure for years, except, of course, as they might come in from outside. Tuberculosis is a more difficult problem, but by guarding the air and food supply and by teaching consumptives how to keep themselves from infecting others great advances can be made toward getting rid of this disease.

Tuberculosis offers perhaps the best example of advance from the physiologic to the etiologic attitude toward disease. The history of recent advance in the study and treatment of tuberculosis has recently been well summarized by R. W. Phillip ("Progressive Medicine and the Outlook on Tuberculosis," *British Medical Journal*, 1909).

The remarkable advance in the medical sciences during the last half century has been due chiefly to the development of research laboratories in universities, in special research institutions and in the government service. In spite of relatively meager funds these institutions have provided instruments and inspiration for search for the truth; the work has been led by men of genius, and has been organized so as to promote cooperation without destroying initiative. For the most part these research laboratories have been connected with laboratories of medical schools, although in this country such connection has been unfortunately too rare. Where such a connection exists, as at Chicago and Rush, the investigator is stimulated by the youth about him while the younger men are inspired with ambition for that real power which comes from scientific knowledge.

In the application of medical science to human needs America has been much more backward than in the advance of medical science. This is due probably chiefly to the fact that a very few men can advance medical science enormously if they be of the caliber to discover essential truths and have the right environment. One or two research institutions or a government inclined to give even meager support to medical investigation makes possible the

work of a Walter Reed, who is primarily responsible for the proof of the conveyance of yellow fever by mosquitoes, or of a Ricketts, whose work on spotted fever and on typhus fever will, in spite of his untimely death, cause his name to be lastingly remembered. On the other hand, in order to have an affective application of medical science to human needs there must be a sufficient number of men well versed in the science to make it possible to educate the whole people to its practical value in the broadest sense. This, owing partly to the backwardness of so many of our medical schools, we have not had. In the Wisconsin legislature, a "progressive" legislature at that, bills relating to instruction in hygiene and to medical inspection in the public schools have failed to pass because a handful of christian scientists exerted more influence than a medical profession of three thousand. On the other hand, this same legislature has been quite liberal in providing for state and county institutions for the care of tuberculous patients, but here there has been public education largely led by laymen.

Demonic medicine to a large extent still holds sway. Among the christian scientists the evil spirit is known as "error," among the chiropractics and similar cults as "dislocated vertebræ," among the people, at large as something vaguely formulated but none the less something to be driven out by various kinds of patent medicines for which each year many millions of dollars are spent. The cures which these various forms of demonic medicine sometimes effect are ascribed by the scientific to the action of the stimulated imagination on the body. This has given rise to a new "psychotherapy" in which the effect of mind on body can be utilized scientifically. Psychotherapy, however, is to be looked upon as a branch of physiologic medicine. Demonic medicine has no longer a place in a truly civilized community.

Hygienic medicine, on the other hand, is a lasting gift from the Greeks to civilized mankind. Its basis is personal hygiene, the right use of exercise and rest of mind and body, diet, bathing, fresh air, sunshine, proper clothing and the like. It is primarily the medicine for the home and must depend largely on the intelligence and education of home-making women. In its more specialized aspects for the cure rather than the prevention of disease it is highly developed in our better sanitariums where regulated exercise, selected diet, hydrotherapy, electrotherapy and the like are carefully designed to restore a weakened individual to healthful strength of body, and in hospitals for the insane where the aim is to restore the mind. During the past fifty years in the hands of trained nurses it has transformed general hospitals throughout the world from places of excessive mortality into the safest places in the world in which to be sick. For years to come it appears that trained nurses are likely to be able best to carry its lessons into the schoolroom and the home as they already have into our hospitals, thanks largely to the genius of Florence Nightingale. Modern surgery owes its triumphs fully as much to the trained nurses in our hospitals as it does to anesthetics or asepsis. School nurses to look after the health of school children under the supervision of medical inspectors, and district nurses to carry the lessons of hygienic medicine into the homes where at present babies are so badly cared for that a fifth of them die in the first year and a third die before the age of five, are essential for the advance of health under the guidance of medical science. To the physician engaged in private

practise the nurse trained in hygienic medicine is indispensable.

The practitioner, although he must be able to apply or to direct others to apply appropriate hygienic measures, is himself primarily responsible for physiologic medicine, for the accurate diagnosis and medical and surgical treatment of the sick individual. He must be able to determine accurately the condition of the more important internal organs and be able to apply drugs or other treatment with due regard for these conditions. While many rough-and-ready methods of diagnosis may be used in the home or at the office, many of the more refined methods are here excluded by lack of time or equipment. Thus only too frequently a serious condition is overlooked at its inception and when discovered is so far advanced as to make a cure difficult or impossible. A large percentage of cases of tuberculosis are not recognized until well advanced, in spite of the recent agitation about the disease. This neglect to recognize tuberculosis early will be a standing disgrace to the profession so long as it exists.

Under present conditions of private practise crude, rough-and-ready methods of diagnosis are in many cases the best that can be utilized. A refined method poorly executed is worth far less than a rough method carefully and intelligently used by an experienced, keen-sighted, thoughtful man. But the public has a right to demand the more refined methods. Within a generation we have seen most of major surgery transformed from the home to the hospital. There the surgeons can depend not only on the nursing staff to provide better hygienic treatment than is possible in the home but he can also in a well-manned hospital depend on the internes to utilize many of the more refined and time-consuming methods of diagnosis. To these factors surgery owes no small part of its success.

In internal medicine the hospital is likewise becoming more and more utilized. Sanitariums with highly developed means for applying hygienic treatment have long been popular in the treatment of chronic troubles. Hospitals have not been sufficiently used for the diagnosis and treatment of disease in its inception and less severe aspects, but everything points to a rapid development in this direction. What is needed is more cooperation and less competition among the physicians in any given community. With better cooperation hospitals fitted for diagnosis and treatment could readily be established in sufficient numbers to give every physician a real hospital connection, except possibly in some very small towns. Each hospital should have a laboratory managed by one or more men skilled in the laboratory diagnosis of disease. There would then be no longer an excuse for mere rough-and-ready methods of diagnosis. Nor would it be necessary for the more scientifically inclined physician to maintain at great personal expense a private laboratory of his own. A greater amount of specialization on the part of the various physicians in a community would likewise greatly add to their efficiency, provided the specialization came on top of, not at the expense of, a broad medical training.

In sanitariums it is customary to make a general charge for room and treatment, special fees being made merely for surgical operations. The physician at the sanitarium, if not the owner thereof, is usually on a salary. At general hospitals the charge is usually for room and nursing, and other hospital care, the patient, if able to pay, paying the physician or surgeon caring for him directly for his treatment. The medical staff of the hospital seldom is

on a salary, although a small sum, in addition to room and board, may be paid the interne. At the Johns Hopkins Hospital, where some of the members of the staff have always had some salary as compensation for their care of the indigent, it has recently been proposed to put all of the members of the regular staff on a salary basis, on the understanding that they are not to engage in private practise. The private patients at the hospital would pay the hospital directly, and not the attending physician or surgeon, for their medical care. How widespread such a movement will become can not at present be predicted. In all probability, however, for many years to come the majority of physicians will depend for their support upon fees from patients rather than upon a salary from a hospital or other organization. The freer use of hospitals by no means precludes this.

On the other hand, it is quite apparent that the custom of the employment of physicians on a salary to give medical attendance to groups of people is growing throughout the civilized world. In public institutions for the care of the criminal, insane and defectives, as well as in the army and navy, this custom has long prevailed and in this country has received the general sanction of the medical profession. The employment of physicians by corporations to look after men in remote districts has also received general sanction. But the profession has not looked favorably on the employment by corporations of physicians to look after employees and their families in settled communities where there is an abundance of private practitioners. Nor has the profession looked with favor on the employment at a salary by lodges and other social organizations of physicians to look after members and their families. "Contract practise," as these forms of practise are called, has a bad name, in large part deserved, because too often a physician will contract to treat for a sum too small to make good service possible. When a fair salary is paid for first-class work no legitimate criticism can be made. Certainly there is nothing sacred about the prevalent system of small fees for visits, fees which resemble in some respects tips to a servant for personal service, except that the physician's fee is less often paid in cash. On the other hand, there is nothing especially to be commended in the custom of the specialist, Robin-Hood-like, to hold up the rich sick to pay for the sick poor. The public at large should pay for its necessary charity.

A physician should be paid for his time and his skill and be paid enough to make it possible for him to give good service and improve himself in his profession. But whether he is paid a salary or a fair amount for a definite service makes little difference. The evil to the medical profession of the medical insurance laws of Germany comes not from the fact that the state hires physicians to treat the insured, but from the fact that the state pays far too little for this service.

Much complaint is made of the large numbers who seek free treatment at dispensaries and hospitals in our larger cities, frequently a quarter or more of the population. It is doubtful if so large a part of the population are either paupers or dead beats. Many can not afford fancy fees and know of no way of getting the best treatment except to go to a dispensary or hospital where treatment is organized. Make it possible for the average man to get the benefits of organized treatment at a moderate charge and a large part of the so-called dispensary and hospital abuse will disappear.

There will doubtless always be some necessity for charity work. The com-

munity should pay the hospital and the physician for such as is really necessary. To what extent, beyond mere charity work, the public should pay for treatment of disease by physicians there is room for an honest difference of opinion. Some would have all medical treatment furnished free by the state, others would have none. Most of the profession, as pointed out above, approve of the state employing physicians in the army, the navy and in charitable and penal institutions. In public educational institutions the state is under special obligations to safeguard the health because of the compulsory features of our educational laws. While much can be done along the lines of sanitation and preventive medicine in the schools, much treatment must be given individual pupils if this work is to be effective. Where the law provides for medical supervision of the schools it usually provides that the family of the child shall be notified of the need of treatment and shall be expected to employ a physician for this purpose, except in charity cases where special provision is made. At present this is probably the most practical system, although only from twenty to eighty per cent. of children needing treatment actually get it. It is most efficient where there are school nurses to follow the children to their homes and explain matters to the parents.

The need of proper medical treatment during school life is illustrated by the son of a well-known physician. The boy was slow in the grades, and took five years to get through college. In some doubt the father allowed him to begin a course in medicine. Soon after he entered the medical school some one suggested he needed eye glasses, although he never had supposed he needed them. When these were obtained a new world was opened, continued study became possible and marked professional success followed. A pair of glasses in the primary school might have saved the boy some years in school and much chagrin.

In normal schools, colleges and universities an increasing amount of attention is being given to caring for the health of the students. This care takes several forms. Instruction in personal and public hygiene is now quite general and is required in a majority of colleges. Departments of physical training designed to promote physical health are also quite general. Committees to look after the sanitation of the grounds and buildings are common, but have not in most cases been given sufficient authority to do really efficient work. Classroom ventilation, for instance, is in general wretched. In several of the universities infirmaries are provided to take care of sick students and in others medical advisers or school physicians are engaged to advise or treat those who are ill. Sometimes a special fee is charged each student to provide funds to cover the cost of this medical service, at other times it is paid for out of general university funds and in some instances treatment is free for poor students while the well-to-do are supposed to pay for services received.

At Wisconsin we have a medical adviser with a staff of three assistant physicians, two nurses, a trained laboratory assistant and an office attendant. Careful medical examinations are made of all freshmen and of such upper classmen as require it. Regular daily office hours are held for consultation with students, office treatment is given and some visiting is done at rooming houses of students confined there by illness, although in severe or prolonged illness the student is expected to get his own physician when he can afford to pay. More treatment is given than was originally contemplated, but our experience in Madison has

demonstrated that mere advice counts for little unless it comes from one whose ability to do commands respect. The hygienic talks given to individual students by the medical adviser and his assistants are far more effective than any public lectures on hygiene could be, because the staff commands the respect of the students by its ability to diagnose and treat disease. This, I believe, will be found generally to be the case in all institutional medicine.

In the diagnosis and treatment of disease etiology plays an important part, but the great triumph of etiologic medicine lies in the possibilities for preventive and social medicine which it has opened up. In preventive medicine the state through education, legislation, inspection and regulation plays an essential part. Preventive medicine can only be made effective where the state employs highly trained men to look after sanitation and hygiene. Nearly all diseases at bottom are social and can be properly repressed only by social cooperation.

Indeed even the most individualistic diseases, congenital defects of various sorts, may be frequently traced either to bad or vicious surroundings of the parents or to a bad ancestral line on one or both sides. Eugenics, the new science which seeks to determine the laws necessary for propagation of an improving species, will have to be studied both by the family physician who is to be a wise councilor and by public health officers who aim to be good teachers and guides. Sociological medicine begins not only before birth, but even before conception. The life of young women must be made healthful, young men must be made to understand the lasting effects to the third and fourth generation of drink and the social vices.

At birth again sociologic medicine has its important part to play. When the clean hospital with its specialists comes to be substituted for the dirty midwife and the so frequently bungling general practitioner years of ill health and suffering will be saved the larger share of our married women and our blind asylums will become one fourth too large. Havelock Ellis estimates that in England in 1891 midwives were responsible for the deaths of three thousand women. They were doubtless responsible for the lifelong suffering of many more. It is estimated that about a fourth of the blindness in our blind asylums is due to lack of proper care of eyes at birth.

During infancy the death rate is frightful. While doubtless the fittest survive, they do not survive in the fittest way. An abundance of well-trained district nurses under careful medical supervision could do untold good in this field of sociologic medicine.

A fifth of the population are in the public schools. Here sociologic medicine has already made a good start. In most of the large cities moderately efficient medical supervision has already been established and in the smaller towns it is beginning. Massachusetts has a state law making it compulsory in the public schools to provide a medical adviser and several states have permissive laws. It is the duty of the medical inspector to see that children suffering from contagious diseases are excluded from the school during the infectious period, to examine for defects in the eyes, ears, nose, teeth and throat, to advise treatment when necessary, and in general to look after school hygiene and sanitation. As already twice pointed out, the school medical inspector has his efficiency greatly increased when school nurses are attached to his staff. It has been suggested, quite wisely, I think, that there be an abundance of school nurses who can not only follow the children to their homes and see that

they are cared for, but also act as district nurses to give advice concerning care of infants and general hygienic conditions. The greatest drawback to medical inspection has been lack of sufficient funds to employ enough specially trained men and women at full time to do the work thoroughly. Open-air schools for weak children and special schools for defectives are a natural outgrowth of medical supervision of school children. Chicago is to be congratulated on the splendid start she has made along these lines.

While we can depend on proper medical inspection in the schools and school and district nursing for a great improvement in personal hygiene and in the popular intelligence concerning medicine and hygiene, the care of the public health will depend in no small degree on efficient officers of public health. At the present time these are rare in the United States.

A vast amount of preventable disease exists for which there is no intelligent excuse. There should be practically no typhoid fever, but thousands die from it yearly. Smallpox should be rare, but in the middle west it is quite common. Most of the contagious diseases could be greatly reduced by more efficient boards of health. The milk supply, in most cities, especially those of moderate size, is far too little intelligently supervised. Fortunately, conditions are changing and within the present generation there should be such a demand for well-trained officers of public health that it will be difficult to keep up the supply. Our medical schools will recognize that the training of public health officers is a duty equally important with that of training practitioners of medicine. At Wisconsin, next year, we are to begin a course in public health and we hope within a short time to find a real demand for such a course. The splendid public health work done by our government in Cuba, the Canal Zone and Manila shows what Americans should soon be doing at home. We need a national health bureau and we need in each state and in each district and municipality in each state thoroughly competent health officers. You young men about to graduate must do your best to promote this movement.

Efficient sanitation depends above all else on public education. In tuberculosis splendid progress has already been made along these lines, but much more remains to be done in the general field. The medical profession should do far more than it has done to educate the public. Sanitary laws will be efficient in a democracy just in proportion to the general intelligence about hygienic matters, and no more.

Medical advance depends, on the one hand, on scientific research, on the other on public education along hygienic lines. Every citizen should be inspired with love of personal and public hygiene as were the Greeks. Every physician should be deeply grounded in physiologic medicine and provided with proper facilities for using it practically. Every officer of public health should know thoroughly the contributions of etiologic medicine. All efforts should be made to promote these most fundamental needs of society. While most of you who are graduating to-day will become private practitioners, most of you will be in a position directly or indirectly to promote scientific medicine, public education and public sanitation. You have had as students at Chicago University and at Rush splendid examples before you in your faculty. With such examples none of you can fail to play well your part in helping in the organization of society along more hygienic lines and in the reorganization of medical practise to better fit the needs of modern society.

C. R. Bardeen

University of Wisconsin

LECTURES ON SOLAR AND TERRESTRIAL PHYSICS

A COURSE of lectures will be given between October 17 and 28, 1911, in the Physical Laboratory of the Johns Hopkins University, by Arthur Schuster, F.R.S., honorary professor of physics in the University of Manchester.

The object of the lectures will be to discuss the cosmical applications of recent advances in physics, to explain the methods of examining correlations between solar and terrestrial phenomena, and to specify the problems of solar and terrestrial physics which seem to call for special investigation.

The following headings are intended to illustrate the general scope of the lectures, but do not necessarily indicate the order in which the subjects will be taken:

1. *Preliminary Considerations.* The ponderomotive forces concerned (gravitation, radiation pressure, electrostatic forces). The laws of radiation (adiabatic, isothermal and radiostatic equilibrium).

2. *The Sun.* The interior of the sun, conditions at the surface due to ejection of electrons. Spectroscopic phenomena and their interpretation. The laws of solar rotation. The sun's corona. Sun-spots and their periodicity.

3. *Interplanetary Space.* Effects of small quantities of matter on thermal and electric conductivity.

4. *The Earth.* Our knowledge of its interior constitution. The age of the earth. The principal phenomena of terrestrial magnetism and atmospheric electricity.

5. *The Earth's Atmosphere*—more especially with regard to its condition near its upper limit.

6. *General methods of investigating periodicities.* Brückner's "35-year meteorological cycle" shown to be non-existent. Lunar effects. Connection between sun-spots and terrestrial phenomena.

DR. CHRISTIAN ARCHIBALD HERTER

IN response to an invitation issued by the President of the Johns Hopkins University and the Committee on the Herter Memorial Lectureship, a meeting in memory of the late Dr. Christian Archibald Herter was held in the lecture room of the Physiological Laboratory on Thursday, October fifth, 1911, at three P.M.

Drs. Welch, Halsted, Abel, Dunham and Flexner spoke of various aspects of the life and work of Dr. Herter and paid tribute to his character and his serviees to medical science.

The following minute was adopted and was subsequently read to the audience assembled at four o'clock to hear Professor Kossel's second Herter lecture, who expressed their respect and approval by a rising vote:

The medical faculty and other members of the Johns Hopkins University, as well as all assembled at the delivery of the sixth series of lectures upon the Herter Foundation, desire to place upon record their sense of the great loss sustained by American medicine and by medical science in the death of Dr. Christian Archibald Herter on December fifth, 1910.

The initiation of Dr. Herter's fruitful activity as a scientific investigator by his work as a graduate student in this university and his active interest in the development of this medical school are sources of especial gratification to the university. Upon this occasion especially we recall with grateful appreciation his generous benefaction in founding, in association with Mrs. Herter, a lectureship which has been and will continue to be a fountain of inspiration and instruction to our faculty and students and to the medical profession.

In the life and work and character of Dr. Herter we recognize the manifestation of rare gifts of intellect and of heart and high-minded devotion to the highest ideals of our profession and of scientific medicine. By valuable contributions to knowledge, by wisely directed and generous material aid in the promotion of medical and biological science, by judicious counsel and active effort and by the widely felt influence of a richly endowed, and singularly attractive and cultivated personality Dr. Herter rendered memorable service to American medicine in behalf of higher professional standards and wider recognition and cultivation of medical science.

In this university and elsewhere the memory of Christian Archibald Herter will be cherished not only as that of a generous benefactor, but also "as a presence to be felt and known" exemplify-

ing love of beauty, broad humanity and loyalty and devotion to the best ideals of the physician and the student of man and of nature.

We desire to express our sympathy with Mrs. Herter and her children in their bereavement and that a copy of this minute be transmitted to them.

SCIENTIFIC NOTES AND NEWS

Professor Alfred G. Compton, professor of physics at New York City College, with which institution he has been connected as instructor since his graduation in 1853, has at his request been retired on a pension.

Sir Thomas Crosby has been elected Lord Mayor of London. He is the first physician to occupy that office though he has had 723 predecessors.

Professor F. P. McKibben, head of the department of civil engineering at Lehigh University, has been appointed consulting engineer by the state committee which is investigating the causes of the disaster at the Austin dam.

The Alvarenga prize, of the Philadelphia College of Physicians, valued at $180, was awarded to Dr. Francis D. Patterson for his thesis on "Parathyroid Glandules."

W. H. Brown, Ph.D. (Hopkins '10), has gone as botanist to the Bureau of Science in Manila.

Dr. Charles Sheard has retired from the chair of preventive medicine at the University of Toronto.

The Geographical Society of France has entrusted to Mr. R. Jarry Desloges the erection of an observatory, more or less temporary, on the high plateaus of North Africa.

Mr. Roy C. Andrews will leave during the last week of November on an expedition to the orient on behalf of the American Museum of Natural History. He will visit the whaling stations of southern Korea, then outfit at Seoul and travel into the mountains of north Korea, a region unknown zoologically.

Dr. Albrecht Kossel, who has been giving the Herter lectures at the Johns Hopkins University, will return to Germany on October 24.

The program of the Geological Conference of Harvard University on September 17 consisted of papers on the shoreline changes in northern and southern Sweden, by Professor D. W. Johnson, and on the landslide at St. Alban, Quebec, by Professor Charles Palache.

Professor Willy Kukenthal, visiting professor at Harvard University, lectured to the Zoological Club on October 19 on his studies on whales.

The Harveian oration before the Royal College of Physicians of London was delivered by Dr. C. Theodore Williams, on October 18.

The *Journal* of the American Medical Association states that a committee consisting of Provost Edgar Fahs Smith, Ph.D., Dr. S. Weir Mitchell, Sir William Osler and Drs. William Pepper, Clarence Payne Franklin and Swithin Chandler, Philadelphia, has been formed to take up the project of erecting at Philadelphia a fitting monument to John Morgan, founder of the first medical school in the United States, and director general of the hospitals and physician-in-chief of the American Army during the revolutionary war.

We learn from *Nature* that it is proposed to erect a memorial to Mungo Park and Richard Lander. A committee has been formed consisting of Lord Curzon, Sir George T. Goldie, Lord Scarbrough, Major Leonard Darwin, Sir Walter Egerton and Sir Hesketh Ball to take the necessary steps to secure funds for this purpose. Both explorers have been honored in their native towns of Selkirk and Truro, but no record of any kind exists in the land to which their lives were consecrated and sacrificed.

In the issue of Science for October 6 the age of Mr. Edward Whymper is given as 61, while it should be 71, as he was born on April 27, 1840.

Sir Herbert Hope Risley, known for his anthropological studies in India, died on September 30, at the age of sixty years.

Dr. Wilhelm Dilthey, formerly professor of philosophy in the University of Berlin, died on October 5 at the age of 77.

PROFESSOR OSKAR KELLNER, director of the Agricultural Experiment Station at Möckern, died on September 22, aged sixty years.

AMONG the positions that will be filled by a New York State Civil Service examination on November 11 is that of inspector in mathematics in the Education Department, at a salary of $2,000.

ANNOUNCEMENT has been made by the board of trustees of Stanford University of a gift of $10,000 made by Dr. Adolph Barkan, San Francisco, professor emeritus of the medical school, for the establishment of a special library dealing with diseases of the eye, ear, nose and throat. A gift of $5,000 from Charles C. Stanford for medical library purposes was also announced.

THE fourth annual meeting of the Association of Official Seed Analysts will occur in connection with the other meetings for workers in agricultural science at Columbus, Ohio, November 17 and 18.

PROFESSOR ALBERT S. BICKMORE has given his personal library and almost unequalled collection of lantern slides to the American Museum of Natural History. The collection comprises more than 20,000 lantern slides, of which about 12,000 are colored.

THE American Institute of Mining Engineers held its 101st meeting in San Francisco beginning on October 10. After the meeting members had arranged to embark on the steamships *Manchuria* and *Siberia,* leaving San Francisco on October 17 and arriving in Yokohama on November 3. It is planned to spend eighteen days in Japan, leaving Yokohama on November 21, arriving in San Francisco on December 7. The excursion in Japan will include trips to the Tokio, Nikko and Chuzenji district, Kiota, Nara, Osaka, Kobe, Ikuno, silver mine, imperial steel works, etc.

A MEETING of the International Commission on Mathematical Teaching was held at Milan on September 18–21, Professor F. Klein presiding. It is stated in *Nature* that the main subjects discussed were: (1) The question of rigor in teaching mathematics, especially geometry. It appears that of European countries Italy is the most wedded to rigorous methods, while Germany and Austria stand at the other end of the scale, and admit intuitive methods freely. France and England adopt a middle course, France inclining toward the Italian practise and England toward the German. It was agreed that Euclid does not satisfy modern standards of mathematical rigor. (2) The question of "fusion," *e. g.,* of geometry with algebra, of plane with solid geometry, of geometry with trigonometry, of solid geometry with descriptive geometry, of analytical with geometrical conics, of differential with integral calculus. (3) The provision of mathematical instruction for students of such subjects as chemistry, biology and economics. Such courses were at one time provided in French universities, but are now entrusted to the schools. In other countries there does not appear to be any systematic provision of this kind. The reports issued by the various national subcommissions were presented; of these, the French reports are now complete; eight of the thirty-four English reports have been issued by the Board of Education (Wyman and Co.), and a large amount of literature has been issued by the German subcommittee, whose labors, however, will not be completed for two years more. Arrangements were made for the educational subsection at the International Mathematical Congress to be held at Cambridge (England) on August 22–28, 1913.

THE new session of the Royal Geographical Society, of which Lord Curzon is president, will be opened on November 6, when, as we learn from the London *Times,* Dr. Fridtjof Nansen will give a paper on the Norsemen in America. On November 20 Dr. Tempest Anderson will give a paper on Volcanic Craters and Explosions. At the next meeting, on December 4, Sir Alfred Sharpe, who has recently retired from the Governorship of Nyasaland, where he has been for many years, will deal with the geography and economic development of British Central Africa. On December 18 Dr. D. T. McDougal, of the

Carnegie Institute, who has been studying on the spot for a considerable time, along with Mr. Ellsworth Huntington, the desert conditions of Arizona, will give a paper on American Deserts. Sir William Willcocks, whose paper on Mesopotamia last session created so much interest, will deal with his further researches on the Garden of Eden and its restoration. Dr. Mackintosh Bell, late director of the Geological Survey of New Zealand, has promised a paper on an Unknown Corner of South Island. Mr. Douglas Carruthers, who has made extensive explorations in Central Asia during the last 18 months, will give a paper, probably in March, describing the results of those journeys. Mr. A. J. Sargent will deal with the Commercial Geography of the Tyne Basin, and Mr. P. A. Talbot with the journeys in the central Soudan along with Mrs. Talbot and Miss Olive MacLeod. In January or February a course of three lectures will be given in the afternoon on the Desert of North Africa, by Captain H. G. Lyons, R.E., F.R.S., formerly director of the Egyptian Survey. The Christmas lectures this session will be, on January 5, by Mr. Julian Grande, the subject being "Amongst the Alps"; on January 8, by Mr. W. Herbert Garrison, on "Our World Wide Empire"; and on January 11 "A Lady's Journeys in the Central Sudan," by Miss Olive MacLeod.

Many glacial moraines contain particles of gold, yet the metal is very rarely so abundant as to make their treatment profitable. This is due to the fact that running water has not had opportunity to concentrate the precious metal scoured by the glacier from the decomposed surface of the mountains. In a short report, however, just issued by the United States Geological Survey, F. C. Schrader gives an interesting account of gold-bearing ground moraines at Kennedy Creek and Libby Creek, Montana. The Kennedy Creek deposit, says Mr. Schrader, is commonly known to mining men who have examined it as ancient lake gravel, but it seems plainly to be a subglacial or ice-laid deposit of till—a ground moraine. The material is evidently derived from the upland mountains on the northeast, whence it was scoured off the surface by the ice sheet, shoved and dragged down the slopes, crushed, ground and finally compressed beneath the ponderous ice mass. The ice sheet probably covered the basin with a thickness of a thousand or more feet for a period of centuries. A most unusual feature is the fact that this glacial deposit does not seem to have been concentrated by later streams nor to have derived its gold from preexisting placers. If this view is correct there must occur in the mountains or uplands to the northeast, in the path of the ice that deposited the moraine, some rich gold-bearing vein or bedrock area as yet undiscovered. Tests made of the deposit in six different shafts fairly well distributed over about half a square mile in the southern part of the basin show the gold content of the deposits to range from 20 cents a cubic yard near the surface to about $5 a cubic yard in the bottom foot of gravel next to bedrock, from which it is readily apparent that the deposits contain considerable gold. By some mining men the amount of gold present in the basin has been estimated at $18,000,000. From the data obtained in the present tests, after reasonable allowance is made for bowlders, which in the lower part of the section constitute about 10 per cent. of the material, the deposit in the southern part of the basin seems to contain on the average about 80 cents a cubic yard, including everything from the surface down to bedrock, or about $4 a bedrock yard. This would amount to about $17,360 an acre, or more than $5,500,000 for the Kennedy placer portion of the area examined. The estimate does not include the neck of the deposit in the downstream outlet, which in places attains a thickness of 80 feet or more and is known to carry considerable gold. In the basin as a whole, if gravel of this grade is present throughout, there is probably more than $11,000,000 worth of gold. The entire district of which Kennedy Creek is a portion is roughly estimated by Mr. Schrader to contain about $100,000,000 worth of gold, much of which, he states, to judge from the attention the district is receiving, will probably be won in the near future.

UNIVERSITY AND EDUCATIONAL NEWS

A FIFTY-ACRE piece of level land recently reclaimed on the Cambridge side of the Charles River basin, between the Harvard and West Boston Bridges, has been selected for the new site of the Massachusetts Institute of Technology. The selection is contingent on favorable action by the city of Cambridge in closing up certain streets.

PRESIDENT W. H. P. FAUNCE announces that $400,000 of the endowment fund of $1,000,000 which Brown University is endeavoring to secure, has already been subscribed. The general education board has contributed $150,000 and eight gifts of $25,000, together with smaller amounts aggregating $50,000, have been received.

MR. CHARLES SCRIBNER has given to Princeton University a completely equipped printing plant, provided at a cost of $125,000.

SIX new buildings are to be erected at the University of Wisconsin during the present school year. The first of these is a $200,000 woman's dormitory, three stories high and of fireproof construction. A feature of this building will be its division into two separate parts, each part to have a separate dining room, parlors, music room, etc., for the women of each section. The second building to be erected is the $115,000 building for the department of home economics and for the extension division. This building will consist of a large central portion with two wings. It will consist of three stories and basement and will be built of pressed brick with stone trimmings. A new building for the department of agricultural chemistry, to cost approximately $100,000, will be started next month. This building will also be constructed of brick and will follow the general lines of architecture of the agricultural engineering building and the agronomy building. The other improvements to be made this year include an annex to the gymnasium and armory, a west wing to the chemistry building and a west wing to the library. The new agronomy building, started last fall, will be ready for occupancy in a few weeks.

DR. ARTHUR S. MACKENZIE, who left the chair of physics at Dalhousie University for the same position at Stevens Institute last year, has been appointed president of Dalhousie University.

DR. BRADLEY M. DAVIS has been appointed assistant professor of botany in the University of Pennsylvania. He will offer work in plant cytology and genetics, and a course on the morphology of the algæ and bryophytes alternating yearly with a course on the morphology of the pteridophytes and gymnosperms.

MR. WINSLOW H. HERSCHELL, technical correspondent of the Allis-Chalmers Company in Zurich, has been appointed assistant professor of mechanical engineering in the University of Maine, to succeed Mr. W. M. Curtis, who has resigned to engage in practical work.

DR. RHEINART P. COWLES has resigned his position as associate in biology in the Johns Hopkins University to enter on his duties as associate professor of zoology in the University of the Philippines.

THE following promotions and appointments have been made in the School of Zoology at the University of Texas: Dr. J. T. Patterson, adjunct professor; Dr. D. B. Casteel, adjunct professor; Dr. A. Richards (Princeton '11), instructor; Mr. W. L. Brown and Miss Charlie Wilson, tutors; Mr. O. R. Lasater, Miss Ethel Taylor and Miss Mary Kirkland, student assistants.

THE new appointees in the College of Engineering of the University of Illinois and the Engineering Experiment Station includes C. R. Richards, B.M.E. (Purdue '90), M.M.E. (Cornell '95), for nineteen years associated with the engineering work of the University of Nebraska and for several years as professor of mechanical engineering and dean of the College of Engineering, has been appointed professor of mechanical engineering in charge of the department. A. M. Buck, M.E. (Cornell '04), for two years assistant professor of electrical engineering at New Hampshire

College, and for the past year professor of electrical engineering at the Clarkson School of Technology, has been appointed assistant professor of railway electrical engineering. F. C. Lincoln, S.B. (Mass. Inst. '00), E.M., Ph.D. (Columbia '11), for three years professor of geology and metallurgy at the New Mexico School of Mines, for three years professor of geology at the Montana State School of Mines, and for the past year in practise in New York City as consulting mining engineer, has been appointed associate in mining engineering. Paul Hanson, B.S. (Mass. Inst. '03), for several years practising sanitary engineer, has been appointed associate in sanitary engineering. G. A. Shook, A.B. (Wisconsin '07), for the past four years instructor in physics at Purdue University, has been appointed instructor in physics. J. W. Hornbeak, B.S. (Ill. Wesleyan '06), A.M. (Illinois '09), assistant in physics at Cornell University, has been appointed instructor in physics. G. A. Goodenough has been promoted from associate professor of mechanical engineering to professor of thermodynamics, and M. L. Enger from associate in theoretical and applied mechanics to assistant professor of theoretical and applied mechanics.

New faculty appointments to the School of Applied Science of the Carnegie Technical Schools, Pittsburgh, for 1911–12, are: Charles B. Stanton, assistant professor of railroad engineering; Clyde T. Griswold, assistant professor of mining engineering; Clinton J. Davisson, instructor in physics; Arden B. Holcomb, instructor in electrical engineering; Joseph H. Cannon, instructor in electrical engineering; H. J. MacIntire, instructor in mechanical engineering; Edgar F. Leippe, assistant instructor in machine design; O. T. Geckler, instructor in mathematics; J. A. Fitzgerald, instructor in commercial practise and statistics; Edwin C. Kemble, assistant instructor in physics; Roy B. Ambrose, assistant instructor in mechanical engineering laboratory.

Mr. G. R. Anderson has been promoted to an associate professorship of physics, Mr. H. W. Price to an associate professorship of electrical engineering and Mr. P. Gillespie to an associate professorship of applied mechanics at the University of Toronto. Mr. T. B. Saunders has been appointed lecturer in vertebrate embryology.

DISCUSSION AND CORRESPONDENCE

COUPLING *vs.* RANDOM SEGREGATION

To the Editor of Science: The suggestion offered by Morgan, in Science of September 22, to account for the coupling and repulsion of factors for various characters in inheritance in such forms as *Abraxas, Drosophila,* fowls, sweet peas, etc., incites this note.

Briefly Morgan's hypothesis is (1) that the materials representing factors that couple are "near together in a linear series" in the chromosomes; (2) that, when pairs of parental chromosomes conjugate, "like regions stand opposed"; (3) that "homologous chromosomes twist around each other," but that the separation of chromosomes is in a single "plane"; (4) that, thereby the "original materials will, for short distances be more likely to fall on the same side of the split," while more remote regions will be as likely to fall on one side as on the other; (5) that, in consequence, whether characters are coupled in inheritance or are independently inherited depends upon the "linear distance apart of the chromosomal materials that represent factors."

Leaving for cytologists to determine what has become of the "individuality" of the chromosomes, we may well inquire whether this hypothesis can account for the facts of Mendelian inheritance as exhibited in coupling, allelomorphism and independent segregation of the factors that represent characters. If parental chromosomes twist together and then separate in a single plane so that materials near together in a linear series are usually left together on one side of the split while more remote materials fall by chance on either side, it would seem that somewhere between these two regions the material representing some one character at least must be divided by the split so that part of it would lie on one side and part on the other. That

is, there would result a quantitative division of the material representing the character in question. This brings us back, at least so far as certain characters are concerned, squarely to the position taken by Morgan last year in his paper: "Chromosomes and Heredity" (*Amer. Nat.*, 44: 449–496).

While the hypothesis there presented, including the proposition that the plane of division of homologous chromosomes may be at any angle to the plane of union and the assumption that a certain quantity of the material representing a character must be present in order that the character develop, will doubtless account for the results (ratios) obtained in F_2 of a cross, *it certainly will not account for the purity of extracted recessives and dominants as exhibited by their behavior in* F_3 *and later generations. To overlook this is to neglect the fundamental part of Mendelism.*

A hypothesis that does not explain how extracted recessives can breed true generation after generation without the production of so much as a single individual having the dominant character will hardly be accepted by present-day students of genetics.

R. A. EMERSON

HIBERNATION

TO THE EDITOR OF SCIENCE: The *Popular Science Monthly* of October, 1910, published an article of mine entitled "The Natural History and Physiology of Hibernation," pp. 356–364. Since this article appeared some additional facts, in natural history, have been brought to my notice as well as some errors bearing on this subject. It is the purpose of this letter to note the former and to correct the latter.

On page 359 will be found the sentence: "Many butterflies and moths hibernate in the perfect state as well as in the form of imagos, but not in the larval state (?)." The correction here is that "*pupa*" should be read instead of "*imagos.*" In the latter part of the same sentence, "but not in the larval state (?)" the statement is wrong, for several butterflies and a great many moths hibernate in the larval state, notably the Noctuidæ and Arctiidæ, consequently the query mark should be abolished.

Again the statement is made, "Insects which hibernate do not pair until spring and bees do not hibernate at all." This sentence is not quite full enough and demands more detailed information or additional light on the subject. All our wild bees, wasps and some others pair in the autumn and the fertile females hibernate. Hive bees, on the other hand, pair in the spring and do not hibernate.

The statement will be found on page 360: "but curiously enough no case [hibernation] is known among birds." I must still hold to this notwithstanding the following account, which may interest your readers, furnished to me in a private communication, by Mr. C. W. Nash, biologist to the Ontario government. I quote in full: "I have found evidence (of a sort) which leads me to believe that the Purple Martin and Chimney Swift may at times become partially dormant and I have recently received from an eye-witness an account of the cutting down of a hollow tree near Peterboro, in the month of January, many years ago; this tree is said to have contained hundreds of swallows in a dormant state, some of which were revived. I have the names of other witnesses of this curious incident and am looking them up."

In support of this suggestive phenomenon one can say that we do not know what part of the world the Chimney Swift does migrate to for the winter but it would be well to remember also that we are equally ignorant of the path the Arctic Tern takes to and from its winter and summer homes, 11,000 miles apart! We are still lamentably ignorant of a great many things about birds.

Mr. Nash supports the statement on page 360 that a low temperature was not the only cause of hibernation. He experimented with Black Bass and found that when the fish were "kept in a warm room they ceased to feed at the end of October and resumed again in March, though they never became dormant—in fact were just about as active during the winter as at any other time, though in nature I do not think they are so." I trust that these

corrections and additions will prove of value to the student of natural history as well as increase the interest in the phenomenon of hibernation.

ALLEN CLEGHORN

DRAFTS AND COLDS

TO THE EDITOR OF SCIENCE: Does it often happen that a writer opposes his own claims so neatly and conclusively as in "Drafts and Colds" in your issue of the 22d?

Those who read about the 16-inch fan will think of the generous third that rests upon a feather or other mattress and is correspondingly warmed while two thirds is fan-swept.

How could a more complete "disturbance of the thermo-neural equilibrium of the surface of the body" be secured and maintained?

(Other inventors prefer the cool blast from an exactly opposite direction.)

H. F. DUNHAM

September 26

"WASHINGTON SCIENCE"

THE communication in SCIENCE of September 29, with the above title, signed "Washingtonian," has doubtless been read with interest by many scientific men in this city and elsewhere. However, the article contains no mention of one feature in government work which in the mind of the present writer constitutes an obstacle to scientific work and a serious defect in the plans of more than one branch of the service. This is the placing and assumption of too much executive responsibility in scientific bureaus in the hands of unscientific subordinates to the chief.

The justification for "red tape" given by "Washingtonian" should have been applied to "system." In this sense the arguments can not be successfully controverted nor is there much more necessity for system in government work than exists in many universities or business houses. The head of a scientific bureau or department, however, has no desire to give routine matters his personal attention and wisely delegates the keeping of records and accounts to a chief clerk or executive assistant known by some other title. It is, however, too often true that these subordinates overstep their original authority and gradually assume more. They may and often do become autocrats in their respective departments or bureaus. "System" then rapidly becomes "red tape." We then have the spectacle of a man without scientific training or experience dictating to the scientific corps how they shall conduct themselves.

Scientific work in an atmosphere such as this is aggravating and, while many of the annoying circumstances are too small to carry to the bureau or department head, as a whole they constitute an objection to scientific work in government service sufficient to have driven more than one good man away. A university may employ a purchasing agent or bursar, but it would, I trust, be difficult to find cases in which a department head receives practically all of his orders from such employees. In Washington it is not so difficult to find such cases. The fault has its origin in the executive's distaste for the details of system, but too often involves the whole corps in the maze of regulations made by men who have nothing else to do and who hunger and thirst for authority. In view of these actually existing conditions the writer may perhaps be excused from openly currying disfavor with the real powers by signing himself merely

ANOTHER WASHINGTONIAN

CHANGES IN THE PERSONNEL OF THE INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE

THE members of the International Commission on Zoological Nomenclature have unanimously invited Professor K. Kraeplin, Direktor des Naturhistorischen Museums, Steinthorwall Hamburg, Germany, to serve on the commission until the next International Congress, in the place of Professor Maehrenthal, deceased; also Dr. P. Chalmers Mitchell, secretary Zoological Society of London, Regent's Park, London, N. W., in the place of Dr. Boulenger, resigned.

CH. WARDELL STILES,
Secretary

October 10, 1911

QUOTATIONS

A LABORATORY FOR EUGENICS

WE publish this morning, and commend heartily to our readers, a very cogent appeal issued by the Francis Galton Laboratory Committee with the approval of the senate of the University of London, and signed by Lord Rosebery, the chancellor, Sir William Collins, the vice-chancellor, Sir Edward Busk, the chairman of convocation, Dr. Miers, the principal, and other members of the committee, asking for contributions towards a sum of £15,000 which is required in order to build the Galton Laboratory for eugenics. It will be remembered that the late Sir Francis Galton bequeathed the residue of his estate, amounting to about £45,000, to the university for the purpose of encouraging the study of National Eugenics, and that he expressed his hope that the university would see fit to preserve the capital wholly or almost wholly intact, not encroaching materially upon it for cost of building, fittings or library. This wish has been strictly respected, and the work of Professor Karl Pearson and his assistants has been conducted under great disadvantages in rooms wholly unsuited for the purpose, although with a vigor and efficiency of which ample evidence has been afforded by some of the controversies to which it has already given origin. The scheme now put forward on the part of the committee would provide a building adequate at least for present needs, on land given for the purpose by the university, and would provide for the safe stowage and the ready accessibility of the numerous pedigrees and other records which are being accumulated in excess of the power of examining and applying them. The committee point out in their appeal that future legislation is likely to deal largely with social problems, and declare it to be essential that the statistical facts on which such legislation may be based shall be analyzed in a purely scientific manner by workers who can give time and energy to investigation, quite independently of any ulterior end or party bias; and they are able to declare that a wide interpretation has already been placed upon Sir Francis Galton's recorded wish that the laboratory "should provide information, under appropriate restrictions, to private individuals and to public authorities." They tell us that they are at present in possession of material, received from educational and health authorities in all parts of the country, which alone would afford three or four years of continuous labor for the existing staff, and the bulk of which has direct bearing upon the most important social and national problems of the day.—London *Times*.

SCIENTIFIC BOOKS

Hygiene and Public Health. By LOUIS C. PARKES, M.D., D.P.H., and HENRY R. KENWOOD, M.B., F.R.S. Edinburgh, D.P.H. London. Philadelphia, P. Blakiston's Son & Co. 1911. 8vo. Pp. 691. Fourth edition with 86 illustrations.

The fourth edition under the conjoint authorship of this work which had previously run through five editions has been carefully revised and brought up to date and will meet the needs of the practitioner and student in a most satisfactory manner. The book contains thirteen chapters, and treats in a very comprehensive manner the following subjects: (1) Water, (2) The Collection, Removal and Disposal of Excretal and other Refuse, (3) Air and Ventilation, (4) Warming and Lighting, (5) Soils and Building Sites, (6) Climate and Meteorology, (7) Exercise and Clothing, (8) Food, Beverages and Condiments, (9) The Contagia-Communicable Diseases and their Prevention—Hospitals, (10) School Hygiene, (11) Disinfection, (12) Statistics, (13) Sanitary Law and Administration.

In the chapter on Water we note with approval the authors' comments on "domestic filters, which are probably more often a source of pollution of the water than otherwise. It is usually considered that a filter requires no attention; it is consequently but rarely cleaned; the filtering material is seldom renewed and its pores become clogged with putrescible organic matter, which form a suitable nidus for the growth and development of living organisms which contaminate the filtered water. It is not unusual under such circumstances to find a considerably larger proportion of organic matter in the filtered

water than was present before filtration." These remarks are especially applicable to so-called gravity filters in which the filtering material is composed of vegetable or animal charcoal, sand, spongy iron, magnetic carbide of iron, polarite and carferal, the latter substance being a mixture of iron, charcoal and clay. It should be distinctly understood that there is no such a thing as a self-cleaning filter and even the Pasteur-Chamberland, Berkefeld and filters of the type in which the water is passed under pressure through hollow porous porcelain cylinders require periodical cleaning at short intervals by a hard brush—otherwise bacteria may in time grow through the cylinder and appear in the effluent; while it has been shown by Dr. Horrocks that the typhoid organisms are not able to grow through the walls of the Pasteur-Chamberland candle, they can grow through the walls of the Berkefeld candles "probably owing to the larger size of the lacunar spaces" and hence the Berkefeld candles should be sterilized in boiling water every third day. On the whole, we may conclude that it is clearly the duty of every community to supply a pure wholesome water, so that domestic filtration may not be necessary.

Among the diseases believed to be produced by impure water the authors refer especially to dyspepsia, dysentery and diarrhœa, typhoid fever, cholera and a number of entozoal infections. The relations of water to goiter and cretinism require further researches. In yellow fever, diphtheria, urinary calculi and rickets, formerly believed to be influenced by the drinking water, the evidence is so indefinite that the water theory has been generally abandoned. Recent observations by Schroeder, of the Department of Agriculture, and others indicate that the germs of tuberculosis are frequently present in the alvine discharges of tuberculous animals and man and by sewage pollution may thus infect the water supply.

Every sanitarian will heartily endorse the authors' chapter on the collection, removal and disposal of excretal and other refuse, because "the public health largely depends on the efficiency with which refuse matters and especially human excretal refuse, are removed from towns; the health of towns in this country and abroad has very much improved, and the death rates have been permanently lowered, as the results of works of sewerage. . . . The pail system is undoubtedly the best for towns which will not enforce the adoption of water closets. In the case of Nottingham, where middens, pails and water-closets are in use in different parts of the town, Dr. Boolbyer has shown that the greatest prevalence of enteric (typhoid) fever is to be found in the houses with middens, and the least in the water-closeted houses, those with pails occupying an intermediate position."

The chapter on Air and Ventilation deals very fully with this important subject. Recent researches clearly reveal that neither an excess of CO_2 or a deficiency of oxygen were responsible for the effects of so-called vitiated air so long as the temperature and humidity of the air were kept low. As soon as the temperature and humidity were increased beyond certain limits there appeared, both in normal and in diseased persons who were submitted to experiment, the usual symptoms that occur when people are crowded together in one room —"*i. e.*, feelings of drowsiness and headache, oppression, lassitude, giddiness, nausea, etc. These symptoms, however, could be relieved at once simply by reducing the temperature and humidity of the air to normal and they may be attributable to heat retention."

In summing up the discussion the authors suggest the importance of "additional research to ascertain the organic constituents (if any) of expired air and to differentiate them from the volatile products of decomposition arising from the general surface and other parts of the body. . . . It may, however, be the fact that whilst nothing of any importance is given off to the air by human respiration and transpiration, yet the air by such means is deprived of some vital element, with which we are unacquainted, and without which the highest state of bodily health and efficiency can not be maintained."

The causal relation of impure air to so-

called acute and chronic crowd poisoning has been recognized for years, and the effects of limited air space upon the undue prevalence of tuberculosis have been repeatedly observed in barracks, prisons, tenement houses, etc., and it is gratifying to be told that "at the present time, other conditions such as food, exercise, etc., remaining much the same, but more air-space and better ventilation having since been provided, the death rate from phthisis is considerably less amongst these servants and prisoners of the state than amongst the civil population."

In another part of the book (p. 456) the authors, in discussing the subject of tuberculosis and the principal predisposing causes, adduce statistical data gathered at Salford and supplied by Dr. Tatham indicating the rôle which "overcrowding" and foul air play in promoting the prevalence of this disease. "Thus, in districts where *all* the houses were built on the vicious system known as 'back to back' the phthisis death rate was 5.2 per 1,000 living; where 56 per cent. of the houses were so built, the rate was 3.6; where 23 per cent. only were so constructed, it was further reduced to 3.3; and lastly where there were *no* 'back to back' houses—that is to say, where all the houses were provided with some means of light and air both in front and to the rear —the rate was only 2.8 per 1,000. These results are all the more remarkable because, with the exception of the absence of means for thorough ventilation, the back to back houses on the whole were, in Dr. Tatham's opinion, in better sanitary condition than the other houses. Similar results have been obtained by other observers and by Dr. Darra Mair, of the Local Government Board (see Report of Medical Officer of the Local Government Board, 1908–9, p. xix)."

Space will not permit to refer in detail to the excellent chapters on Warming and Lighting, Soils and Building Sites, the Hygiene of Dwellings, Exercise and Clothing, all of which contain valuable information of general and personal interest. In the chapter on Food, Beverages and Condiments much space is devoted to Professor Chittenden's work on "Physiological Economy in Nutrition with special reference to the Minimal Proteid Requirements of the Healthy Man." His elaborate experiments conducted with three classes of men, namely, *A*, five professional men (brain workers); *B*, thirteen United States army soldiers representative of men undergoing moderate physical work; and, *C*, a group of eight university students, all being thoroughly trained athletes and engaged daily in arduous physical exercise, have shown that health and vigor without loss of body weight, when equilibrium has once been established, can be maintained on a diet containing only from one third to one half of the proteid prescribed in the generally accepted dietary standards of Voit, Ranke, Moleschott and this without any increase and even, in some cases, with diminution in the non-nitrogenous elements of the diet. These investigations are of great economic and physiologic importance, since it involves not only a tremendous waste of expensive food material, but also a waste and loss of energy of vital forces in excessive metabolism and possibly also the accumulation of toxic waste products in the blood, which are believed to be the cause of degenerative diseases and premature death.

The authors declare that Professor Chittenden's conclusions "have been by no means universally accepted by physiologists and others interested in the construction of dietary scales, as they seem opposed to the general experience of civilized nations; and however interesting as indications of the adaptability of the human frame and functions to alterations in nutrition for comparatively short periods, the experiments were hardly of sufficiently long duration to warrant conclusions applicable to the life of a community for long periods. . . ."

We believe that there is no subject in the realm of physiology more important than the determination of reliable dietary standards. We have been extremely careful in other machines to study fuel economy and to use only those substances for the generation of force which are proper and no more than is absolutely necessary. Opposition fosters the spirit

of inquiry, and we sincerely trust that Professor Chittenden and his opponents may continue these painstaking experiments with a view of determining these vexed questions.

We quite endorse the views of the authors on the subject of food preservatives and have always maintained that the addition of chemicals should not be tolerated as long as we possess in pasteurization, sterilization, refrigeration, pickling and smoking efficient means. The book on page 354 refers to Dr. Wiley's feeding experiments in 1905–7 which demonstrated "that formic aldehyde, boric acid and salicylic acid are substances which when added to food, even in small quantities, may exercise a harmful effect on digestion and health. Few of these agents enter normally into the constitution of the human body, and at least they must be regarded as foreign bodies whose ingestion works no possible good, and which, not being foods, do not in any way make amends for the additional work of elimination which their presence demands. Moreover, they enable venders or manufacturers to deal with stale or badly prepared food, to the prejudice of the more honest tradesman."

The chapter on School Hygiene will be read with pleasure and profit by all who are interested in the prevention of disease and physical defects and the prevention of permanent disabilities.

Anti-typhoid Vaccination.—In the chapter on Communicable Diseases we note the following paragraph: "The value of anti-typhoid inoculations is now obtaining general recognition. The latest report of the results of anti-typhoid inoculation in the British army in India (Army Medical Department Report, 1908) show that the attack rate in inoculated men is reduced to rather less than one half, and the case mortality to about two thirds of the rates in men who have not been inoculated. The protection conferred by two inoculations appears to be somewhat greater than that conferred by one. The material generally used for anti-typhoid inoculation is a suspension of the dead bacilli obtained from a culture killed by heat."

We have observed very much better results quoted by Major F. F. Russell, of the medical corps United States army, in *The Military Surgeon* for June, 1909. The statistics were taken from Col. Leishman's report in the *Journal* of the Royal Army Medical Corps, 1909, XII., p. 166, and indicate that for one case of typhoid among the inoculated there are ten among the uninoculated and that for one death among the inoculated there are ten among the uninoculated. Dr. Russell also refers to the results of inoculations among the expeditionary forces in German Southwest Africa reported by Dr. Mursemold, showing that the man who refused inoculation was twice as liable to have typhoid as the man who accepted and four times as apt to die of it.

It is extremely gratifying to state that the greatest triumph in the prevention of typhoid fever in military camps has been achieved by the medical corps of the United States army, as shown by the experience of the maneuver division at San Antonio, Texas, from March 10 to July 10, 1911. This division, composed of 12,801 officers and men, had one case of typhoid fever and no death, while the second division of the seventh army corps, with 10,759 officers and men, assembled at Jacksonville, Fla., during the Spanish-American war in 1898, had 2,693 cases of typhoid fever with 248 deaths. "This division," writes Col. Kean, of the medical corps, in the *Journal of the American Medical Association,* August 26, 1911, "was not conspicuously unfortunate in its typhoid record for that time and is selected because of the close similarity of its conditions of service to those of the maneuver division. The two divisions were encamped in nearly the same latitude and for about the same length of time, and each had a good camp site and an artesian water supply of unimpeachable purity."

While it is true that camp sanitation was rigidly enforced, especially as regards the disposal of wastes, no new sanitary principle was evolved, and we are forced to conclude that the protective inoculations played the most important rôle. Anti-typhoid vaccination was

introduced into the United States army largely through the efforts of Major Russell, of the Army Medical School, and was made compulsory for the officers and men of the maneuver division. Dr. Russell recently wrote me that over 45,000 of our troops have now been vaccinated without any untoward results. He says: "This is the first time in the history of preventive medicine that compulsory immunization against typhoid fever has been used, and no military camps have ever been so free from this disease."

We have given considerable space to the presentation of this subject, not only because it is a distinct triumph for American preventive medicine, but the lessons taught should be applied in civil practise so as to avert a needless sacrifice of life and money from one of the so-called preventable diseases.

GEO. M. KOBER
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Evolution. By J. ARTHUR THOMSON and PATRICK GEDDES. No. 14 in the Home University Library of Modern Knowledge. New York, H. Holt & Co. 1911. Pp. 256. Price, 75 cents.

Another successful collaboration by the two well-known biological writers, Professors Geddes and Thomson, has produced a small but stimulating volume, "Evolution," which is the fourteenth in the new English-American series called, rather heavily, the Home University Library of Modern Knowledge. The earlier collaboration by these writers twenty years ago resulted in a book, "The Evolution of Sex," that has become a biological classic.

"Evolution" is, of necessity, largely a restatement of things already frequently and variously stated. The series to which it belongs is meant for popular consumption and has a standard that determines pretty definitely the activities of its contributors. The facts and their significance, where this significance is not too uncertain, and these facts and inductions set out with some attention to interestingness as well as clearness and accuracy; these are requirements of the series. The authors of "Evolution" have, of course, no difficulty in making their volume almost a model from this point of view.

But they have been able to add color and personal character to the book, to boot. Especially in the chapter (VI.) on "Organism, Function and Environment, in Relation to Evolution," and in VII., "Evolution Theories in their Social Origins and Interactions," and VIII., "The Evolution Process Once More Interpreted," is the personal point of view revealed. And these chapters, especially, therefore, will interest "constant readers" of evolution literature.

I have lately had occasion to say, in a review of another of Professor Thomson's books, that he is a good selectionist; though not a bad one; that is, that he is not a selectionist bigot. "However," it was added, "Darwinism for him rests on, or is, mostly selection." It is of particular interest therefore, to note that in this latest personal utterance of Professor Thomson, Darwinism, or, more fairly, evolution, is less and less chiefly selection. Indeed the closing sentences in the present book—of course they are words of Geddes and Thomson, not Thomson alone—are:

> Natural selection remains still a vera causa in the origin of species; but the function ascribed to it is practically reversed. It exchanges its former supremacy as the supposed sole determinant among practically indefinite possibilities of structure and function, for the more modest position of simply accelerating, retarding or terminating the process of otherwise determined change. It furnishes the brake rather than the steam or the rails for the journey of life; or in better metaphor, instead of guiding the ramifications of the tree of life, it would, in Mivart's excellent phrase, do little more than apply the pruning-knife to them. In other words, its functions are mainly those of the third Fate, not the first: of Siva, not of Brahma.

The whole chapter of which this paragraph is the conclusion is a plea for a sort of vitalism—to misuse again, probably, a usually misused word. It is a sort of vitalism that assumes some cause, inherent in life or pertinent only to life, capable of producing a "definite variation, its branchings essentially dichotomous rather than indefinite, with prog-

ress essentially through the subordination of individual struggle and development to species-maintaining ends."

All these changes and others, in fact the most important of floral variations, the big lifts distinctive for the evolution of orders, are thus seen no longer as indefinite, and hence dependent on external selection for their guidance; but, on the contrary, as parallel and definite, since determined through the continued checking of the vegetative process by the reproductive, and thus pressed along parallel and definite grooves of progressive change. But if this be so, the importance we have been taught by Darwin to assign to natural selection becomes greatly changed—from selecting accumulating supposed indefinite variations, to that mainly of retarding definite ones, after their maximum utility has been independently reached!

Despite, or perhaps because of, the clarifying definitions of vitalism given us by Professors Lovejoy, Ritter and others, I am now come to a point where I do not know at all what vitalism means. I once had at least a personal meaning for the word. But as I note the references to Driesch and Bergson in this book of Professors Geddes and Thomson and then read their chapter—Geddes and Thomson's chapter—on "The Evolution Process Once More Reinterpreted," and see that natural selection is for them the work "of Siva, not of Brahma," I am going hereafter to think of them as vitalists! To such a misunderstanding of vitalism and vitalists can one come through persistent reading about things and persons thus catalogued!

But let no one avoid this excellent little book about evolution because of fear of taint from vitalism. Probably no one else will find any vitalism in it; the authors perhaps least of all! V. L. K.

Stanford University, Cal.

British and Foreign Building Stones. A Descriptive Catalogue of the Specimens in the Sedgwick Museum, Cambridge. By John Watson.

Under the above caption Mr. John Watson has published a compact little volume of 483 pages descriptive of a collection of building stones prepared by him and installed in the Sedgwick Museum of Cambridge, England. The collection comprises upwards of eleven hundred specimens prepared in the form of 4½ inch cubes "the sides of which are dressed in the usual style adopted for the purposes for which the stone is generally used in the region from which the specimen comes." Each specimen is accompanied by a label giving the commercial name of the stone, its stratigraphical position, name and locality of the quarry and name and address of the owner. The individual labels state the color, average chemical composition, weight per cubic foot, and crushing strength so far as data are available.

Two hundred and forty-four pages of the catalogue are, however, given up to descriptive matter in which the stones are taken up according to their geological distribution, and it is this portion which will be of greatest value to those not having immediate access to the collection.

The collection is arranged according to the geological horizons, with the exception of the igneous rocks, which are divided into plutonic and volcanic. The portion of the work relating to the rocks of Great Britain contains much interesting historical matter and observations relative to the weathering of the rocks.

No illustrations are attempted, but there is a very full index and it is evident that a great deal of discrimination has been made in getting together the collection as well as in compiling the book which deserves the name of "handbook" rather than simply "descriptive catalogue."

George P. Merrill

THE ASTRONOMICAL AND ASTROPHYSICAL SOCIETY OF AMERICA

The twelfth annual meeting of the Astronomical and Astrophysical Society of America was held in the Dominion Observatory, Ottawa, Canada, on August 23, 24 and 25, 1911. In opening the first session, President E. C. Pickering called attention to the fact that this was the first meeting of the society held outside of the United States. Welcome to Ottawa was extended to the society by Dr. W.

F. King, director of the Dominion Observatory, whose remarks were prefaced by the reading of an official welcome in behalf of the Canadian government, communicated by the Deputy Minister of the Interior, W. W. Cory, C.M.G.

Five sessions of the society were devoted to the reading and discussion of papers, to the reports of committees and to routine business. In addition the society's program was amplified by an opportunity extended the visiting members to examine the work and the equipment of the Dominion Observatory. Following this inspection a resolution was unanimously adopted as follows:

Resolved, That the Astronomical and Astrophysical Society of America, assembled at the Dominion Observatory for its twelfth annual meeting, has examined in detail the work of the observatory, and expresses its very favorable opinion of the character of the investigations carried on in all of its departments. This is particularly the case with the determinations of radial velocity, from which unusually valuable results have been obtained by means of a telescope of comparatively small size. In view of the pressing need for such data, the society hopes that a more powerful telescope may soon be provided, and one in keeping with the standing now attained by the national observatory of Canada.

Aside from the purely astronomical program of the meeting several most enjoyable social features were arranged for the members and friends present, whose appreciation was expressed in an unanimous resolution of thanks to Dr. King and his staff.

The list of members in attendance is as follows: Miss Bigelow, Miss Cannon, Miss Furness, Miss Palmer, Miss Swartz, Miss Whiting, Messrs. Apple, Bailey, Chant, Curtiss, C. L. Doolittle, Douglass, Eichelberger, Frisby, Harper, Jordan, W. F. King, Littell, Manson, Marsh, McDiarmid, J. A. Miller, Motherwell, Peters, Plaskett, Russell, Schlesinger, Slocum, Stebbins, R. M. Stewart, Tatlock, Tucker and A. B. Turner. In addition several friends of the society were in attendance.

The following eighteen persons were elected to membership: Mr. C. A. Bigger, Dominion Observatory, Ottawa, Canada; Mr. Leon Campbell, Harvard Surcursal, Arequipa, Peru; Dr. E. A. Fath, Mount Wilson Solar Observatory, Pasadena, Cal.; Mr. Alexander Sarkis Galajikian, Cornell University, Ithaca, N. Y.; Mr. Curvin H. Gingrich, Goodsell Observatory, Northfield, Minnesota; Mr. William Pratt Graham, 1205 Harrison St., Syracuse, N. Y.; Professor Thomas F. Holgate, Northwestern University, Evanston, Ill.; Mr. Louis Allen Hopkins, Ann Arbor, Mich.; Dr. Otto Klotz, 437 Alberta St., Ottawa, Canada; Mr. Carl Otto Lampland, Lowell Observatory, Flagstaff, Arizona; Rev. D. B. Marsh, Springville, Ontario, Canada; Mr. Richard John McDiarmid, Dominion Observatory, Ottawa, Canada; Mr. R. M. Motherwell, Dominion Observatory, Ottawa, Canada; Miss Margaretta Palmer, Yale Observatory, New Haven, Conn.; Mr. Harry B. Rumrill, Berwyn, Pa.; Mr. R. M. Stewart, Dominion Observatory, Ottawa, Canada; Miss Psyche Rebecca Sutton, 813 Market Street, Logansport, Indiana; Mr. Warren J. Vinton, The Wellington, Detroit, Mich.

A committee on cooperation in the teaching of astronomy was appointed with membership as follows: Professors C. L. Doolittle (chairman), Sarah F. Whiting, C. A. Chant and J. A. Miller.

The following officers were selected during the meeting:

President, E. C. Pickering; *First Vice-president*, E. B. Frost; *Second Vice-president*, W. W. Campbell; *Secretary* (for three years), W. J. Hussey; *Treasurer*, C. L. Doolittle; *Councilors* (for two years), W. S. Eichelberger, J. S. Plaskett; *Editor for the meeting*, R. H. Curtiss. The terms of office of W. J. Humphreys and F. Schlesinger as councilors did not expire at this meeting.

The next annual meeting of the society will be held at the Allegheny Observatory, Pittsburgh, in August, 1912. The society will also meet at Washington in December, 1911, in connection with Section A of the American Association for the Advancement of Science.

Papers (thirty in number) and reports read at the various sessions of the Ottawa meeting are given below in abstract.

Photographic Determination of the First Point in Aries: E. C. PICKERING. (Read in connection with the symposium on Photographic Astrometry.)

Absolute positions of the stars can probably be obtained by photography, with errors no greater than those of visual determinations, if a telescope can be made to remain in a fixed position during twenty-four hours. The most favorable conditions would probably be attained by mounting the telescope underground, pointing south at an altitude nearly equal to that of the sun. Azimuth observations with meridian circles indicate, in some cases, that an entire hill has a progressive motion. This is obviously improbable in a level plain. Great pains must be taken to connect the objective

rigidly with a metal plate nearly in the focal plane and that this combination shall remain fixed. Rigidity is not required in any other parts of the apparatus. The plate has two holes illuminated by incandescent lamps which when lighted form minute points on the photograph. A circle about two centimeters in diameter is silvered in the center of the objective, whose aperture is reduced to this amount. Several exposures on the sun are made at noon automatically by the clock, moving the plate in declination after each exposure by an amount equal to the diameter of the sun. At the same time a current passes through the lamps which thus impress two reference points upon the photograph. At night the same or another plate is exposed for a second or so to the stars, using the full aperture, and the position of the trails with regard to the reference points, compared with that of the sun, gives the relative positions.

Photographs were exhibited showing images of the sun and stars upon the same plate.

The Spectra of 762 Double Stars: Annie J. Cannon.

A list was prepared of all stars in the "General Catalogue of Double Stars" by Burnham, and the "Reference Catalogue of Southern Double Stars" by Innes, in which the components are of magnitude 7.5, or brighter. A special examination of the Harvard photographs was made to determine the spectra of these stars.

Classification of some Stellar Spectra Photographed with the Slit Spectroscope at the Allegheny, Lick and Yerkes Observatories, Compared with those taken at Harvard with the Objective Prism: Annie J. Cannon.

The Draper classification of stellar spectra depends wholly on photographs taken with the objective prism. In view of the fact that a large number of photographs is being made with the slit spectroscope at various other observatories, it appears to be a matter of great importance to make a comparative study of these spectra, and to determine whether the same system of classification will apply to spectra obtained by these two widely different methods. Accordingly, a preliminary study has been made of 131 spectrograms, including spectra from Class Od to Class Md.

The Spectra and Colors of Red Stars of Harvard Classes N and R: J. A. Parkhurst. (Read by Dr. Slocum.)

In June, 1911, Professor E. C. Pickering sent the writer a list of "Fourth Type Stars not Red" (Class R). This list was extended to include an assortment of ordinary red stars (Class N). An investigation of the spectra of these stars was made from plates taken with the objective prism on the 6-inch Zeiss camera and with the Brashear spectrograph on the 40-inch Yerkes refractor. The "Color-Index" was found by comparing the photographic magnitude with the so-called "visual" magnitude obtained with color-sensitive plates and the "visual luminosity" filter, on plates taken with the Zeiss camera and the 2-foot reflector.

The paper, which will be published in full in *Astrophysical Journal,* gives results for 17 stars, for which the "color-indices" range from 1.11 to 5.60 magnitudes. The principal conclusions are:

1. Excepting the first star, which apparently has a composite spectrum, all are as red or redder than *α Tauri,* and therefore seem to deserve the name of "red" stars.

2. No sharp line can be drawn between the Classes N and R.

The Orbits of the Spectroscopic Components of d Bootis: W. E. Harper.

Fifty-three spectrograms of this F-type star, photographic magnitude 5.3, form the basis of the determination of the elements of the orbit. The plates were obtained mostly with the single-prism instrument, but for considerably over half the period of 9.60 days the spectra were separated and measures were made on each component. Elements were determined for each by the method of least-squares, after preliminary elements had been obtained graphically. These were in substantial agreement with each other; but a more rigid determination was effected by combining the observation equations of the two components into *one* set of normal equations, thereby deriving uniform values for the elements.

Studies of Bright Variable Stars: Joel Stebbins.

Observations with the selenium photometer have been continued during the past year, and the paper contains results for three stars, *α Orionis, δ Orionis* and *β Aurigæ. α Orionis* is a well-known irregular variable, and the results for 1910–11 indicate a range of 0.2 mag. *δ Orionis* has long been suspected of variability, but it is now shown to be an eclipsing variable with two minima, the range being about 0.10 mag. The third star, *β Aurigæ,* has also been found to be an eclipsing variable with a range of less than 0.10 mag. A combination of the photometric and spectroscopic results gives the actual dimensions of this binary

system, and the complete work will soon appear in the *Astrophysical Journal.*

The Variability of Polaris: EDWARD S. KING. (Read by Professor Stebbins.)

The variability of Polaris having been announced by Professor E. Hertzsprung, I examined the results obtained by photographing stars out of focus, contained in Nos. 4, 5 and 6 of H. A. 59, to discover what evidences of such changes might be afforded.

The corrections given for the individual plates were used to show changes in Polaris for the different nights. The spectroscopic period, 3.9683 days, was accepted. A separate grouping according to phase was made for each of the three investigations. The light curves derived from these three independent series of observations are all of practically the same form and amplitude as Hertzsprung's, and confirm his discovery. The curve derived from Nos. 5 and 6 of H. A. 59 suggested a sine curve. And such a curve was found to represent the ten points given by the grouping. A sine curve having an amplitude of 0.108 mag. is a very close approximation. The residuals, expressed in thousandths of a magnitude, for the ten points are $+6$, $+2$, -9, $+6$, $+8$, -4, -6, $+5$, -7 and $+3$. The average deviation is ± 0.0056.

The effect of the variability of Polaris on the magnitudes already determined by the out-of-focus method was practically eliminated by the nature of the reduction employed in the original work. Corrections were made which included any variation in the light of Polaris, or any change in the conditions occurring between photographing Polaris and the stars observed. The effect was the same as if Polaris had been known to be variable.

No special plates or measures have been made to obtain the above results. All the material has been derived from matter already in type.

A Study of Visual Binary Stars: HENRY NORRIS RUSSELL.

1. The masses of visual binary systems computed from their observed parallaxes vary through a wide range, as Aitken has recently shown. But if "hypothetical" parallaxes are computed on the assumption that the mass of each of these systems is 2.4 times that of the sun (the average for the twelve best determined systems) only five out of 26 observed parallaxes differ from these hypothetical values by quantities greater than might be expected in view of the probable errors of the former. The average difference between the observed and hypothetical parallaxes in the twelve best determined cases, corresponds to a probable error of only one fifth of the latter (including all errors of observation). It is evident that the binary stars are much alike in mass, and that the assumption of equal masses gives very good approximations to the true distances, etc., of these systems.

2. It is well known that a relation between the density P and the surface brightness J of a binary star can be obtained independent of its parallax. Let M and L be the actual mass and luminosity (the sun being standard), r the radius, π the parallax and l the apparent brightness (in suitable units). Then (assuming a single mass)

$$L = Jr^2 = \frac{l}{\pi^2}; \quad M = \rho r^3 = \frac{a^3}{\pi^3 l^2};$$

whence

$$\rho J^{-\frac{3}{2}} = ML^{-\frac{3}{2}} = \frac{a^3}{l^2 l^{\frac{3}{2}}}.$$

The values of $\rho J^{-3/2}$ for the individual components may be found when the ratios of their masses and luminosities are known, and (as experience shows) estimated with sufficient accuracy for the brighter component from the observed difference in magnitude.

Applying this to 83 binaries (the spectra of 29 of which, determined by Mrs. Fleming and Miss Cannon, were very kindly furnished the writer by Professor Pickering) it is found that the whiter stars are very much brighter for equal masses than the redder ones, while the stars of any one spectral type are much more similar in brightness.

The average masses of 73 of these binaries were determined by means of their parallactic motions on the assumptions (1) that the stars of a given spectral type are of equal mass; (2) that they are of equal luminosity. The two sets of values agreed closely, showing both methods to be equally legitimate.

3. For most "physical pairs," shown to be so by common proper motion, only the apparent distance and the rate and direction of the apparent relative motion are at present known. The masses, and related quantities, for the average of groups of ten or more such stars, can be found by a statistical process. Let r be the true distance, and V the true relative velocity in space; a the major axis of the orbit; s the observed distance, and w the observed relative velocity, as projected on the celestial sphere; i_1 and i_2 the angles between r and v and the line of sight; M the mass and π the parallax of the system.

Then $s = r\pi \sin i$, $w = v\pi \sin i_2$, and by gravitational theory

$$v^2 r = K^2 M \left(2 - \frac{r}{a}\right),$$

where the constant K^2 is 39.7 of the sun's mass; the astronomical unit and year are taken as units. Hence

$$\frac{sw}{\pi^3} = 39.7 M \sin i \sin^2 i_2 \left(2 - \frac{r}{a}\right).$$

The last three factors are unknown, but their average values can be predicted on principles of probability. This gives the formula

$$M = \frac{sw^2}{18\pi^3}. \qquad (1)$$

The average of the values given by (1) for a large number of stars will be practically correct. The percentage of individual cases in which the error of this formula may be expected to lie between given limits has been calculated, showing that the mean derived from ten cases will probably be within 10 per cent. of the truth.

4. This method has been applied to all available physical systems brighter than the sixth magnitude, 276 in all, raising the whole number of stars discussed to 349. All the principal spectral types are well represented.

For about half these stars, the relations between mass and surface brightness are very similar to those already found among stars for which orbits have been computed. The other half (including all the stars of type B and some of every other type) are *very much brighter in proportion to their mass* than those previously studied. These stars are probably similar to the stars of great luminosity to which Hertzsprung has called attention under the name of "giant stars." The others may be called "dwarf stars." In type A the two kinds run together, but among the redder stars they are more and more widely separated, though a few intermediate cases exist.

Among the giant stars the relation of mass and brightness is much the same for all spectral types, the values of $\rho J^{-3/2}$ ranging from 0.004 to 0.002 (the sun being the standard). Among the dwarf stars the brightness falls off very rapidly with increasing redness. $\rho J^{-3/2}$ being 0.03 for type A, 0.30 for F, 1.2 for G, 4.8 for K, and rising to over 2,000 for certain faint stars of large parallax whose spectra appear to be of types K_5 or M (with the exception of one aberrant star of type A).

5. The average masses of the giant and dwarf stars of each spectral type have been determined from the parallactic motions (assuming constant luminosity for the stars of each group 25 to 60 in number).

All the giant stars appear to be similar in mass —a system of this sort having about 10 times the mass of the sun. The average masses of the dwarf stars decrease with increasing redness —that of a system of type F being some three times the sun's mass, and of one of type K rather less than the sun's.

The average light emission of a pair of giant stars is from 150 to 250 times that of the sun (the latter for type B). That of the dwarf stars diminishes from 30 for type A to 4.5 for F, 1.3 for G, 0.3 for K and 0.01 for the faint stars already spoken of. It appears therefore that the more massive stars are by far the brightest.

6. The average densities of stars of types B, A and F can be found with the aid of Algol-variables of these types, and the surface brightness may then be deduced from the values of $\rho J^{-3/2}$ already found.

Allowing for the fact that in the average Algol-variable the brighter star is decidedly the smaller of the two, the following values are found—those for type F being uncertain, and the sun being throughout the standard.

	Giant Stars			Dwarf Stars	
	F	*A*	*B*	*A*	*F*
Density	0.04?	0.09	0.13	0.45	0.6?
Surface brightness	4.5?	7.2	15.0	6.1	1.7?

The very faint stars of spectra K_5 and M, even if of ten times the sun's density, can not exceed 1/30 of its surface brightness.

These values agree closely with those derived from the work of Wilsing and Scheiner on stellar temperatures (based on the distribution of energy in the spectrum).

They afford an independent confirmation of the hypothesis that the effective surface temperature of a star is the principal factor which determines its spectral type.

7. Assuming that the surface brightness of giant and dwarf stars of the same spectral type is the same (and interpolating values for spectrum K with the aid of Wilsing and Scheiner's results) it is found that the mean density of the giant stars increases steadily with *decreasing* redness from less than 1/10,000 that of the sun for type M, and 1/1,000 for type K, to 1/8 for type B. That of the dwarf stars increases with *increasing*

redness, the average density for types G and K being about that of the sun.

8. It may be added that all these facts (except the existence of one very faint star of type A) are in harmony with the scheme of stellar evolution sketched by the writer last year.

The 6-inch Transit Circle of the U. S. Naval Observatory: F. B. LITTELL.

Work has been begun with this instrument on a list containing the old or historical fundamental stars, and the new fundamental stars as proposed by the International Committee of the Photographic Chart of the Sky. The instrument is fairly satisfactory as to its errors, which are either quite constant, or are readily determined for any instant by interpolation between values observed at suitable intervals. The pivots have been measured with great accuracy by the axial microscope method. Their irregularities are very small. The division errors of the degree lines of circle A have been determined, also the periodic errors of the two-minute lines within the ten-minute spaces. The periodic and progressive errors of the telescope micrometers and of the microscope micrometers have been measured.

The zenith distance micrometer is used for declination work. Readings are made on two circle divisions under each of the four microscopes, using two pairs of threads in each, distant 2.5 revolutions of the micrometer screw from each other. A hand-driven self-registering right ascension micrometer is used. A reversing prism is used, by means of which each observation is taken half with image direct and half with image reversed. The instrument is reversed from clamp east to west and *vice versa* at short intervals.

In order to test the performance of the instrument a list of 30 stars was observed 4 times in each of 8 positions of the instrument; *i. e.*, direct and reflected (D.R.), clamp east and west (E.W.), and with objective and eye-end interchanged (I., II.). Circle A was used in fixed position, and circle B was shifted each night. The level errors were determined from nadir observations.

Right Ascension.—By a discussion of the differences E.–W. and R.–D. the following flexures were wound:

Lateral flexure varying as cos $2z$

$+ 0^s.005 \pm 0^s.001$ (DEI)

Axis flexure varying as cos $2z$

$- 0^s.025 \pm 0^s.002$ (DEI)

The following tables show the quantities indicated before and after the application of the corrections due to the above flexures.

	Azimuth of Marks			
	North Mark		South Mark	
	Observed	Corrected	Observed	Corrected
	s	s	s	s
Clamp E. I.	−0.055	−0.018	+1.040	+1.077
" W. I.	+ .010	− .027	+1.132	+1.095
" E. II.	− .067	− .030	+1.049	+1.086
" W. II.	+ .022	− .015	+1.132	+1.095

In the next table each quantity is the mean for 3 stars and each has been multiplied by cos δ.

	Right Ascension Uncorrected for Flexure											
	½ (D–R)				½ (W–E)				½ (II–I)			
2 DS	E, 1	W, 1	E, II	W, II	D, 1	R, 1	D, II	R, II	E, D	E, R	W, D	W, R
	s	s	s	s	s	s	s	s	s	s	s	s
+55°	+.006	+.012	−.005	+.001	−.001	−.007	+.004	−.002	−.010	+.001	−.007	+.007
49	− 1	+ 17	− 12	+ 15	+ 6	− 12	+ 20	− 7	− 9	+ 2	+ 4	+ 7
44	− 4	+ 4	0	+ 8	0	+ 3	+ 2	− 6	0	− 5	+ 3	− 2
27	+ 3	− 4	+ 4	− 1	− 5	+ 2	− 4	+ 1	+ 4	+ 3	+ 5	+ 3
+12	− 4	− 9	+ 2	− 13	+ 7	+ 12	+ 8	+ 22	+ 2	− 4	+ 3	+ 6
−11	+ 3	+ 3	+ 3	− 5	+ 8	+ 8	+ 8	+ 15	+ 5	+ 5	+ 4	+ 12
20	− 3	+ 6	− 8	+ 2	+ 2	− 7	+ 16	+ 6	− 1	+ 5	+ 15	+ 17
32	− 11	+ 4	− 12	− 2	+ 13	− 2	+ 25	+ 16	0	0	+ 12	+ 17
46	− 17	+ 24	− 11	+ 19	+ 26	− 16	+ 33	+ 2	+ 6	0	+ 14	+ 17
−58	− 22	+ 32	− 25	+ 30	+ 32	− 22	+ 39	− 15	0	+ 4	+ 8	+ 8

By the application of the flexure corrections the probable error of a single observation in right ascension is reduced from 0.0266 sec. δ to 0.0204 sec. δ. For direct observations it is reduced to 0.0190 sec. δ.

The above error is entirely eliminated from the mean of an equal number of clamp east and clamp west observations.

The following table gives the comparison with the right ascensions of Newcomb (N), and those of Boss (B), tabulated as above.

Declination.—From measures on the collimators and from a discussion of the observed declinations in different positions of the instrument the following corrections were determined. Some confirmatory results from short series of direct and reflected observation taken in 1909 are also tabulated.

Dn is a constant correction to reduce direct observations of north stars to the mean of direct and reflected, and *Ds* is a similar correction for south stars.

By the application of the corrections due to the flexures, etc., as determined from the observations, the following improvements are made in the mean differences taken without regard to sign:

	Circle A			Circle B		
	D–R	W–E	II.–I.	D–R	W–E	II.–I.
Uncorr'd for flexure	0.″60	0.″34	0.″30	0.″54	0.″43	0.″40
Corr'd for flexure...	0.22	0.23	0.26	0.30	0.37	0.38

The probable error of a single observation is reduced from 0″.62 to 0″.34 for circle A and from 0″.58 to 0″.44 for circle B.

	Right Ascension, Corrected for Flexure							
	½ (D–R)				½ (W–E)			
Z. D.	E, I	W, I	E, II	W, II	D, I	R, I	D, II	R, II
	s	s	s	s	s	s	s	s
+55°	+.011	+.007	.000	−.004	−.003	+.001	+.002	+.006
49	+ 3	+ 13	− 8	+ 11	+ 4	− 5	+ 18	0
44	− 1	+ 1	+ 3	+ 5	− 2	+ 7	0	− 2
27	+ 1	− 2	+ 2	+ 1	− 4	− 1	− 3	− 2
+12	− 11	− 2	− 5	− 6	+ 10	+ 2	+ 11	+ 12
−11	+ 1	+ 5	+ 1	− 3	+ 4	+ 1	+ 4	+ 8
20	+ 1	+ 2	− 4	− 2	− 7	− 8	+ 7	+ 5
32	+ 3	− 10	+ 2	− 16	− 6	+ 7	+ 6	+ 25
46	+ 5	+ 2	+ 11	− 3	0	+ 2	+ 7	+ 20
−58	+ 4	+ 6	+ 1	+ 4	+ 2	+ 1	+ 9	+ 8

Coefficients of		Circle A. 1910	Circle B. 1910	Circle A. 1909
sin *z*, I.	From colls.	+ 0.″33 ± 0.″03	+ 0.″27 ± .03	
sin *z*, I.	" star obs.	+ .45 ± .05	+ .51 ± .05	+ 0.36
sin *z*, II.	" colls.	− .13 ± .03	.00 ± .03	
sin *z*, II.	" star obs.	+ .31 ± .05	+ .44 ± .05	
cos *z*, II.	" " "	+ .07 ± .02	+ .13 ± .02	+ .01
cos *z*, II.	" " "	+ .17 ± .02	+ .09 ± .02	
cos 2*z*	" " "	+ .18 ± .02	+ .09 ± .02	+ .10
Dn		− .21 ± .03	− .23 ± .03	− .24
Ds		− .28 ± .03	− .16 ± .03	− .11

Z. D.	Right Ascension	
	O B S.–N	O B S.–B
	s	s
+ 55°	+ 0.020	− 0.008
49	+ .030	+ .015
44	+ .009	+ .008
27	− .005	.000
+ 12	+ .004	− .006
− 11	− .001	− .004
20	+ .000	− .005
32	− .010	− .011
46	+ .009	+ .009
−58	+ .003	+ .004

Z. D.	Circle A—Boss		Circle B—Boss		Boss–N
	All Obs.	Direct Obs.	All Obs.	Direct Only	
+ 55°	+ 0.″30	+ 0.″74	+ 0.″27	+ 0.″67	− 0.″35
49	+ .16	+ .71	+ .05	+ .48	− .33
44	+ .31	+ .96	+ .23	+ .66	− .21
27	+ .37	+ .75	+ .39	+ .77	− .36
+12	+ .48	+ .76	+ .35	+ .55	− .24
−11	+ .17	+ .32	+ .31	+ .48	− .19
20	+ .40	+ .50	+ .34	+ .49	+ .02
32	+ .39	+ .44	+ .35	+ .40	+ .13
45	+ .13	+ .11	+ .17	+ .07	− .09
− 58	+ .04	+ .05	+ .05	+ .08	+ .05

All of the cosine flexures considered above are completely eliminated from the mean of an equal number of clamp east and clamp west observations. The following table gives comparisons with the declinations of Boss, and the reduction from Boss to Newcomb. The direct observations were re-

duced with the sine flexure determined from the collimators. The corrections $\Delta\phi = +0''.2_0$ for circle A and $+0''.14$ for circle B, based on direct observations of circumpolars observed at both culminations have been applied.

The Alt-azimuth Instrument of the U. S. Naval Observatory: F. B. LITTELL.

The telescope of this instrument is of 5 inches aperture and 50 inches focal length. The graduated circle is 23 inches in diameter, read by 4 microscopes magnifying 30 times. Two levels are used on the alidade. For stars at more than 10° zenith distance, the Pulkova vertical circle method has been used in observing the declinations of stars. For stars at less than 10° zenith distance, the instrument has been used in the meridian, and a double observation has been secured by bisecting with the micrometer at a side thread before and after reversal about the vertical axis.

The essential differences between the use of this instrument for declinations and that of a meridian circle are: (1) that the double zenith distance of the object is measured; (2) that each observation is complete in itself and does not depend on the stability of the instrument except for the short interval, 5 or 6 minutes, covered by the observation; (3) that cosine flexures are immediately eliminated; (4) that spirit levels are substituted for the mercury horizon in determining the reference point of the circle, and (5) that in the Pulkova method a time observation is substituted for a micrometer observation. This latter method, however, may be adapted to meridian circle work by slightly inclining the zenith distance thread, and it has been thus used by some observers.

In general the differences seem to be favorable to the use of the vertical circle and it is probably the best type of instrument yet devised for obtaining fundamental declinations. The use of the micrometer to obtain additional bisections may lead to the securing of greater accuracy.

About 5,000 observations made by the writer from December, 1903, to July, 1907, have been reduced. One of the levels used in the early part of the work did not give satisfactory results, but for the last 3 years of the work, the levels performed in a fairly satisfactory manner. During that period the element of probable error due to levels (mean of two) in a declination resulting from a single observation was $0''.035$.

The division errors were not measured, but their effect was reduced by reading on two divisions under each microscope and by shifting the circle. The probable error of a single observed declination due to division error is $0''.15$

The sine flexure was measured in 1910 after the installation of horizontal collimators. From 14 sets of measures the value $+0''.79 \pm 0''.063$ has been adopted.

The variation of latitude as given by the International Geodetic Commission has been applied.

From 1,190 observations on 134 circumpolar stars at both culminations, the following correction to the latitude, $\Delta\phi$, and correction to the refraction constant, ΔR, were obtained:

$$\Delta\phi = +0''.50 \pm 0''.090,$$
$$\Delta R = -0''.22 \pm 0''.056.$$

As the separation of $\Delta\phi$ and ΔR was not well determined, it was assumed that $\Delta R = 0$ and the resulting value $\Delta\phi = +0''.15 \pm 0''.017$ was adopted.

The accidental error of a single observation, not including division error, is shown in the following table:

Z. D.	No. O B S.	Probable Error
0°–10°	766	± 0.′284
10 –30	1496	.243
30 –50	1340	.276
50 –70	1220	.335
70 –75	328	.465

On account of the construction of the instrument, it is difficult to observe stars near the zenith and this probably accounts for the larger probable error of stars from 0° to 10° as compared with those from 10° to 50° zenith distance.

Z. D.	No Stars	Obs. N	Obs. B
285°–290°	42	—0.″03	+0.″03
290–300	54	— .08	— .06
300–310	22	— .12	— .20
310–320	27	— .17	— .10
320–330	60	+ .35	+ .31
330–340	68	+ .02	+ .07
340–350	69	— .20	+ .11
350– 0	102	+ .05	+ .32
0– 10	96	+ .22	+ .58
10– 20	114	+ .31	+ .56
20– 30	113	+ .30	+ .53
30– 40	115	— .01	+ .34
40– 50	100	+ .23	+ .57
50– 60	89	+ .41	+ .72
60– 70	71	+ .32	+ .47
70– 75	15	+ .42	+ .52

The comparisons of the observed declinations with those of Newcomb (N) and those of Boss (B) after the application of the corrections for

sine flexure and $\Delta\phi$ are as follows. The signs have been changed for sub-polars.

In addition to the above observations there are about 2,500 made by Mr. Geo. A. Hill and Mr. H. B. Evans from 1898 to 1903, which are nearly reduced. A preliminary survey indicates the following relative personal equations for declinations of the south stars:

$$H\text{–}L = -0''.2,$$
$$E\text{–}L = -0''.4.$$

Some experimental work to clear up this matter will be undertaken before combining these observations into a catalogue.

The Earth's Radiation Zones: W. J. Humphreys. (Read by Professor Eichelberger.)

Since heat may be transferred from one object to another only by conduction, convection or radiation, therefore by measuring the temperature of the isothermal region of the atmosphere, in which both conduction and convection are small, it is possible to determine the radiation intensity of the earth at as many places as one may wish.

The effective radiating level, as determined by Abbot and Fowle, has an average elevation of about 4 kilometers, consequently the lower clouds are within the radiating surface while the cirri are above it. Hence the latter, and they alone, can strongly affect the intensity of the outgoing radiation.

An extensive exploration of the upper atmosphere with sounding balloons has shown that, probably because of the unequal distribution of cirri, the intensity of the earth's escaping radiation within the tropics is to that of latitudes 35° to 60°approximately as 3 to 4. In fact, as a radiator the earth has an inefficient equatorial zone, efficient zones of middle latitudes, and finally, for which there is some evidence, inefficient polar caps.

The Amount and Vertical Distribution of Water Vapor on Clear Days: W. J. Humphreys. (Read by Professor Eichelberger.)

It is important to any one using a bolometer, or a pyrheliometer, to know the approximate amount of water vapor through which the radiation reaching his instrument has passed. In attempting to determine this amount the records have been brought together of 74 balloon flights, made on cloudless days, or such as were adapted to the ordinary use of the bolometer.

According to these data the amount of water vapor per unit volume decreases with elevation on *cloudless* days in an approximate geometric ratio, and the thickness of the water layer that would result from a condensation of all the water vapor in the atmosphere on such days above any given level may be approximately expressed by the equation

$$d = 2e,$$

in which d is the depth of the water layer in millimeters, and e the partial pressure of the water vapor, at the place of observation, in millimeters of mercury. This value is about 13 per cent. less than that given by Hann for all sorts of days, and heretofore commonly used in bolometric work.

Daytime Laboratory Work in Astronomy: Sarah F. Whiting.

The list of members of this society includes those responsible for the teaching of astronomy in more than fifty colleges and universities. It seems therefore in order that the society should take cognizance not only of the research work by which knowledge is increased, but also of the teaching by which it is diffused.

From not very detailed information it seems probable that the methods of teaching generally used in elementary classes are not those of the other sciences.

Daytime laboratory work in astronomy by the students themselves requires a teaching force, an equipment of instruments and photographs, and a place for the work, which has not yet been demanded by the departments of astronomy nor provided by the institutions. No less research work should be done by the observatories, but the teaching should not be allowed to suffer. Useful apparatus and photographs which are the material for daytime work will never be provided by dealers in apparatus till a sufficient number of institutions adopt modern methods of teaching to make a demand for such material. Also larger numbers of students should take an elementary course in astronomy to lessen the deplorable ignorance which exists.

Other learned scientific societies have lent valuable aid to the advancement of elementary teaching. May it not be for the advancement of astronomy for this society to consider the teaching of those beginning classes from which the professional astronomers and the patrons of the observatories must come?

On Scales of Intensity for the Lines of the Solar Spectrum: Frank W. Very. (Read by Mr. De Lury.)

A spectral line not appreciably broader than an image of the slit, and perfectly black, may be

rated as 10 on an absolute scale of intensity, and the strength of any line in absolute units is the product of its width by the intensity of its absorption, multiplied by a constant. The constant may be chosen so that unity coincides with Rowland's unity, and it is found that in this case the above definition is very closely fulfilled, although Rowland's numbers diverge considerably in other parts of the scale.

From a smooth curve which represents the true photometric intensities of ultra-violet lines on negatives by Higgs, the significance of Rowland's symbols has been found to be as follows:

$R_{0.1} = 0000 = .05$	$R_1 = 1.05$	$R_6 = 10.60$	$R_{11} = 21.40$
$R_{0.2} = 000 = .15$	$R_2 = 2.57$	$R_7 = 12.80$	$R_{12} = 23.55$
$R_{0.3} = 00 = .25$	$R_3 = 4.30$	$R_8 = 14.95$	$R_{13} = 25.70$
$R_{0.4} = 0 = .35$	$R_4 = 6.30$	$R_9 = 17.05$	$R_{14} = 27.85$
	$R_5 = 8.40$	$R_{10} = 19.20$	$R_{15} = 30.00$

These values have been confirmed by measures in the green.

It is shown that, in general, the relation between the width and the intensity of the photographic images of spectral lines is not as simple as has been assumed. It is also shown that differences of width of spectral lines have been exaggerated in Thollon's Atlas, doubtless in order to convey a more realistic impression of the intensities.

Periods of Variable Stars in the Small Magellanic Cloud: HENRIETTA S. LEAVITT.

(Read by Professor Russell.)

The periods of 25 of the variable stars in the Small Magellanic Cloud have been determined, and have been found to vary in length from 1.25336 days to 127.0 days, while the light curves are of the cluster, sometimes called the "ant-algol" type. The brightness and the length of the period are so closely related that if one is known, the approximate value of the other may be inferred. For an increase of one magnitude in brightness at maximum or minimum, the logarithm of the period increases by about 0.48. It seems possible that all these variables are of similar mass, those whose periods are long having slight densities, and *vice versa*. On account of their faintness, it is impracticable to obtain their spectra, with our present facilities. A number of brighter variables having similar light curves, as UY Cygni, are in isolated positions, and should repay careful study not only of their spectra, but, if possible, of their parallaxes. Among other questions suggested are the following:

1. Are there definite limits to the mass of variable stars of the cluster type?

2. Does the spectra of such variables having long periods differ from those of variables whose periods are short, and how?

The Radial Velocities of 96 Herculis: S. A. MITCHELL.

Preliminary results from the measures of twenty-five spectrograms of 96 Herculis taken with the one-prism Bruce spectrograph of the Yerkes Observatory show the presence of four components and a period of 50.2 days. On account of the large velocities, which range on the plates measured from — 98 kilometers per second to + 74 kilometers per second, it was possible to measure three separate components on half the plates, and four components on a few of them. The components all belong to the B-type.

This interesting system will be followed closely, and more definite results will be given when more plates are obtained.

The San Luis Observatory of the Carnegie Institution: R. H. TUCKER.

The first part of the expedition sailed from New York in August, 1908.

Ground was broken for the observatory, on land set aside by the national government, a month later.

The piers were built of reinforced concrete, and the observatory and dwelling of brick, with wooden roofs covered with rubberoid. The shutters for the meridian circle building were constructed at Albany, before starting, and were taken out by freight along with the rails for the floor, instruments for preliminary adjustment, chronometer and one of the astronomical clocks.

Five months later the dwelling was ready for the staff of ten men, and the observatory was completed for the installation of the Pistor and Martins instrument of the Dudley Observatory.

Observing on the regular list was begun in April, fundamental and miscellaneous observing being taken up. The full list contained 15,000 stars. About 1,600 of these were fundamentals, of varying degrees of precision; from 4 to 32 observations were taken of each; usually the observations have been in excess of the requirements. The first year 61,000 observations were made, though, from the time observations were in full swing, 62,000 were made in one year. About 300 nights were available for observations, of which 200 were clear throughout, in the first year. At the close of the work, in January, 1911, there had been made 87,000.

These were taken in 650 series, of which a full night would include two.

Above 300 fundamental series had been made, each including the observations for groups of primary clock stars twelve hours apart, and those for the combination of successive upper and lower culminations of one or more circumpolar stars.

For the study of the refraction 3,000 observations of stars at large zenith distances were made.

For the corrections to the instrument, collimation had been regularly observed; flexure at the beginning and end of the work; pivot error and division error were measured with sufficient detail to confirm the more elaborate investigations at Albany; and 400 reflection observations were obtained, an average of 40 for each ten degrees employed.

For the personal corrections of the observers, over 2,000 determinations of the magnitude equation were made, by the five telescope observers.

Special determinations of the value of the screen employed accompany this correction. For the bisection error and transit error (N.–S.) 1,750 observations were made. The difference of eye and ear minus chronograph was determined for the observers.

The instrument was dismembered in February of this year, and was returned to the Dudley Observatory, where the reductions will be completed.

Short Formula for Computation of Circum-meridian Azimuths: C. C. Smith. (Introduced by Dr. W. F. King.)

A short formula for the computation of azimuths observed near the meridian is here given. The ordinary formula for azimuth requires the use of a subtraction logarithm. In the short formula $1 + \cot \delta \tan \phi \cos t$ is expanded in a series and after rearrangement and reduction gives a formula for azimuth which requires the looking up only of the natural logarithm of the declination, after which the multiplications may be quickly carried out on the arithmometer. The formula is much shorter and gives less chance for error than the ordinary formula, especially where a considerable number of observations have been taken at each station.

Changes in Collimation and Level of the Ottawa Meridian Circle: R. M. Stewart.

This paper deals with the observations made at Ottawa from March to December, 1910. Measurements of collimation and level were made usually twice in the course of an evening's work; the changes during the interval (four hours on the average) are here investigated. The average change of collimation was $+ 0''.03$ for Clamp East and $- 0''.20$ for Clamp West; these changes run with great regularity, changing invariably with the reversal of the instrument, and appear to be entirely independent of seasonal and temperature changes or of the interval between the observations. The changes of level were not sensibly affected by reversal of the instrument, but there is some evidence of a small seasonal effect.

Preliminary Measures of the Solar Rotation: J. S. Plaskett.

This paper is a first contribution towards the scheme of cooperation in determining the solar rotation by the Doppler displacement of the spectral lines, which was organized at the meeting of the Solar Union at Mt. Wilson last September. A large amount of preliminary work which is briefly described has been performed for the purpose of ascertaining the most suitable apparatus and methods for accurate work. The mean of 23 rotation plates, obtained in June and July of the present year, gives, at the equator, a velocity of 2.034 ± 0.004 kms., the probable error of a single plate from the mean of the plates being ± 0.017 km. The average probable error of a single line is ± 0.021 km., varying from ± 0.010 to ± 0.030 km. in the different plates.

The measures of upwards of 50 spectra, in the region allotted to this observatory λ 5,500 to λ 5,700 give no definite indication that the velocity due to any particular lines or elements differs from that of the general reversing layer. Tabulating the residuals from the lines on these plates, it is found that the mean residual, taking account of the signs, is in only one case, and that a faint and diffuse line, equal to as much as one half the average numerical residual. Furthermore, the measures of twelve plates of the spectrum of the sun's limb, which had impressed upon them an arbitrary displacement of the same magnitude and character as the rotation plates, differing from the latter only in the displacement being the same for each line, show small varying displacements of different lines of the same order as those obtained for the rotation plates. It is probable, therefore, that in the region under consideration there is no systematic difference in the velocities of rotation obtained for different lines or elements, the very small differences observed being probably due to the character of the lines for measurement.

Preliminary Report on the Photographs of Halley's Comet taken at Honolulu, H. I., by Ferdinand Ellerman in 1910: E. E. BARNARD. (Read by Dr. Slocum.)

The expedition for the observation of Halley's comet, sent in 1910 to the Hawaiian Islands by the Astronomical and Astrophysical Society of America in the sole charge of Mr. Ferdinand Ellerman, established itself on the south slope of Diamond Head about five miles southeast of Honolulu, Oahu Island, and at an elevation of about one hundred and fifty feet above sea-level.

The instrumental equipment consisted of a Warner and Swasey mounting with a six-inch Clark lens, loaned by the Lick Observatory; a metal camera with a Brashear six-inch portrait lens of thirty-two inches focal length, loaned by Brashear; and a wooden camera with a two-and-one-fourth-inch Bausch and Lomb Optical Company-Zeiss Tessar lens of nine and seven eighths inches focus, loaned by the Bausch and Lomb Optical Company. The cameras were carried on the telescope tube.

Mr. Ellerman secured an excellent series of photographs of the comet and made very important though negative observations at the time of the comet's transit across the sun on May 18. On this date, though small spots could be distinctly seen on the sun's surface, no trace of the comet or its nucleus was evident.

Visual observations of the extent of the tail of the comet on the mornings of May 15, 16 and 17 accord with observations made elsewhere. In the record of May 24 occurs the following note: "Nucleus of comet appeared double or dumbbell-shaped. Separation estimated about 20″ of arc."

Mr. Ellerman secured sixty photographs of the comet with the six-inch Brashear camera and thirteen with the Tessar. Many of these photographs are exceedingly interesting, but in the main they agree with other photographs in showing that very little of the abnormal occurred in the phenomena of the comet's tail. One thing apparent in the phenomena of Halley's comet which was first shown in Daniel's comet was the fact that on several occasions two slender streams, which doubtless had their original intersections in the nucleus, receded from the head still connected as if the source of supply were going out with them.

The length and breadth of the tail of Comet Halley as shown on Mr. Ellerman's Tessar plates are here tabulated.

Near its extremity the tail was always very faint on these photographs. On the plate of May 14 at least twelve degrees of the forty-nine recorded was very faint.

Date, 1910	Length of Tail	Width	At Distance from Head
May 4	28°	2.7°	18°
5	31	4.0	19
6	21	2.6	16
7	27	3.1	18
8	24	3.1	18
9	30	3.7	18
11	32	4.3	27
12	43	2.3	27
14	49	4.3	38
28	32	6.6	23
June 1	15	1.8	12

The Solar Prominence of October 10, 1910: FREDERICK SLOCUM.

This paper is based upon a series of photographs taken in the light of calcium with the Rumford spectroheliograph of the Yerkes Observatory, and upon some hydrogen photographs, nearly simultaneous, taken by Mr. Ellerman at the Solar Observatory, on Mount Wilson.

The prominence extended from latitude $-24°$ to latitude $-40°$ in the east limb, and reached a height of 105,000 km. In connection with the spectroheliograms are discussed the relations of hydrogen and calcium images, absorption effects due to dark masses projected against bright prominences and gravitational effects upon prominence particles.

Direct photographs of the H and K region of the spectrum between λ 3,910 and λ 3,980, were made with the slit across different parts of the prominence. These show the H_3 and K_3 lines following sinuous courses throughout the whole lengths of the H_2 and K_2 lines. The local relative displacements of the emission and absorption lines amount to $\pm$ 0.20 A, corresponding to velocities of about 15 km. per second if the displacements are manifestations of the Doppler effect.

Vapor-density Effects on the Calcium Lines H, K and g: OLIVER J. LEE. (Read by Dr. Slocum.)

The experiment discussed in this paper was undertaken because of the writer's interest in the anomalies shown by these lines of calcium in radial velocity work, and limits itself to determining the relative vapor-densities at which self-reversal occurs.

The high temperature, about 2,500° C., required to vaporize and incandesce calcium makes the usual apparatus for experiments on vapor-density quite useless. The rate of volatilization of the element under standard conditions was assumed to

be constant and was made the basis of the experiment. The apparatus devised consists of a carbon rod, mounted in a spindle and made to rotate between the poles of a right-angled arc fed by a 20-ampere direct current at 40 volts. The end of the rod is bored to receive charges of the metal up to .5 gram. The inside of the bore is projected by a lens upon the slit of a concave grating spectrograph.

The calcium was introduced into series of tubes in two different ways: (1) The tubes were filled with a supersaturated solution of calcium chloride diluted in multiples of two; (2) uniform slivers of metallic calcium each of weight about 2 mgr. were weighed out into charges of from 5 to 100 mgr. and placed in the heating tubes. Each tube was charged only once, and two to five exposures of 20^s each were made with it. About 800 photographs were taken with 225 tubes. The temperature of the bore was determined from a curve constructed with currents and melting points of refractory metals as arguments. The approximate effect of the calcium impurities in the carbon tube and the air was obtained and allowed for.

Conclusion: The lines g, λ 4,227, and H, λ 3,968, require for reversal vapor-densities that are about 1/7 and 3/2 as great, respectively, as that necessary for a reversal of K, λ 3,933, when the vapor is observed at a temperature of 2500° C. and at atmospheric pressure.

(To be published in the *Astrophysical Journal.*)

Radial Velocity of Halley's Comet as Derived from a Spectrogram: Edwin B. Frost. (Read by Dr. Slocum.)

The radial velocity of Halley's comet on May 24, 1910, as determined by the writer from the displacements of the Fraunhofer lines, was + 55 km. per second. The velocity calculated from the ephemeris of the comet agreed with this value within a kilometer.

Note on the Magnitudes of the Stars in the Cluster, Messier 3: S. I. Bailey.

Certain globular clusters appear to be composed of two groups of relatively bright and faint stars, with few stars of intermediate magnitudes. This appearance has been noted by Pickering, Palmer, Fath and the writer.

A recent plate taken by Ritchey on Mount Wilson with the 60-inch reflector, having an exposure of four hours, shows extremely faint stars. An enlargement of this plate, loaned for this purpose by the acting director of the Solar Observatory, was used for the present discussion. The faintest stars shown appear to be of magnitude 21.5. The number of stars is probably not less than 30,000. An enlargement was made with a réseau dividing the photograph into 1,280 squares. The magnitudes of all the stars in 160 of the squares were determined by comparison with the sequence selected for the study of the variables in the cluster. The number of stars thus measured was 2,542. The scale of magnitudes as extended to the fainter stars may be somewhat in error.

Grouped by magnitudes, the number of stars of each magnitude from 13.5 to 21.5 is as follows: 2, 6, 16, 31, 43, 221, 576, 1,071 and 573; the total light derived from the groups in percentages are: 11, 20, 15, 11, 6, 12, 13, 10 and 2. The light of stars fainter than magnitude 21.5, if such exist, is probably negligible. The stars of the four groups, 13.5 to 16.5, give 57 per cent. of the light of all the stars measured, and those of the four groups, 18.5 to 21.5, 37 per cent. The group at 17.5 may be regarded as intermediate, and here the light is a minimum. The total light of the 2,542 stars whose magnitude was determined is approximately equal to that of a star of magnitude 10.4.

From the relation between the known magnitude of the whole cluster regarded as a single object, and that portion studied in the present paper, assuming that the distribution of the stars by magnitudes is the same throughout, the whole number of stars in the cluster may be derived. This number will be in error, if the scale of magnitudes employed is incorrect. By an independent determination of the number of stars by count, the error in the scale of magnitudes, if any, may be determined.

Tables of Effective Wave-lengths of Lines in Stellar Spectra: S. Albrecht. (Read by Mr. W. E. Harper.)

This paper is a report of progress in the work, begun in 1906, of determining the effective wave-lengths of spectrum lines in stellar spectra. The writer has determined tables of wave-lengths for each of the main divisions of the Draper classification (as modified by Miss Cannon) from types B to M, both inclusive. The part of the spectrum covered is from λ 4,236 to λ 4,655. The work is based on measures made, while at the Lick Observatory, on spectrograms taken with (*a*) the Northern Mills three-prism spectrograph having λ 4,500 central with Ti-spark comparisons; (*b*) the Southern Mills three-prism spectrograph, λ 4,450 Central and Ti-spark comparisons; (*c*) the

same Southern Mills spectrograph but with λ 4,340 Central and Fe-spark comparison spectra. These tables are preliminary to the more extensive investigation which has been made possible by the generous loan from observatories in different parts of the earth of suitable sets of spectrograms.

The relative accuracy attained, though naturally not quite equal to that of the International secondary and Kayser's tertiary standards, apparently approximates these in each set of measures separately for a large number of the lines which are best suited for accurate measurement. Differences of a systematic nature were encountered which might easily have escaped notice if the work had been based upon only one instead of three practically different sets of spectrograms.

A large number of lines has been found, in addition to those already published, whose wave-lengths vary progressively from type to type.

Inasmuch as the accuracy attainable in the relative wave-lengths of lines in stellar spectra, with a good modern three-prism spectrograph, is not much inferior to the accuracy of the available standards of wave-length, it is important for the future progress in this work that results show clearly on what line or group of lines any newly determined wave-lengths are based. Designations like "On the Rowland system" are not sufficient. Results should be published in such form as to be readily convertible to any standard system. This should be done with due regard to the increasingly necessary precaution to condense published results as much as possible without impairing their usefulness.

Wave-lengths of the Silicon Lines λ 4,552.7, λ 4,567.9 and λ 4,574.9 in Stellar Spectra and in Laboratory Spectra: S. ALBRECHT. (Read by R. J. McDiarmid.)

Among the lines whose wave-lengths were dedetermined as part of the extensive program referred to in my preceding note are the three silicon lines λ 4,552, λ 4,567 and λ 4,574, which were first identified with silicon, in stellar spectra, by Lunt. It is not within the scope of this paper to go into much detail. The principal object, besides giving the wave-lengths in stellar spectra, is to call attention to the need of more extensive study of these lines in the laboratory. This will be evident from the tables given below. In table I. are given the wave-lengths of these lines as determined from stellar spectra. For purposes of comparison with the wave-lengths obtained from the Lick spectrograms, I have computed the wave-lengths from the measures of Frost and Adams, published in the Publications of the Yerkes Observatory, Vol. 11. Table II. gives a summary of the determinations of the wave-lengths in stars and in the laboratory.

TABLE I

Based on	In Stars	Determined from		
		Types	No. of Spectrograms	No. of Stars
Lick spectrograms...	4552.752	B to B2	47	7
	.798	B3 to B5	8	4
Mean.....	*4552.759*	B to B5	55	11
Yerkes spectrograms	4552.770	B to B3	42	10
	.717	B5 to A	5	3
Mean.....	*4552.765*	B to A	47	13
Lick spectrograms...	*4567.970*	B to B5	49	9
Yerkes spectrograms	*4567.963*	B to A	44	12
Lick spectrograms...	*4574.916*	B to B3	41	6
Yerkes spectrograms	*4574.920*	B to A	22	9

TABLE II

Wave-length in Stars			Laboratory Values			
			With High Dispersion		With Low Dispersion	
Albrecht	Gill	McClean	Exner & Haschek	Frost & Brown	Lockyer	Lunt
4552.762	4552.79	4552.6	*4552.75*	*4552.64*	4552.8	4552.75
4567.967	4567.90	4567.5	*4567.95*	*4567.90*	4568.0	4567.82
4574.918	4574.68	4574.5	*4574.9*	*4574.79*	4574.9	4574.86

The values of the wave-lengths in stars, table I., as determined from the Lick spectrograms and from the Yerkes spectrograms are in very close agreement. The early determinations by Gill and by McClean, which are added in columns 2 and 3 for the sake of completeness, were, I believe, determined with low dispersion. The laboratory values, table II., by Exner and Haschek (*Aph. Jour.*, 12, 49, 1900) and by Frost and Brown (*Ibid.*, 22, 159, 1905) were both determined with high dispersion. The wave-lengths by Exner and Haschek are slightly smaller, 0.016 Å, on the average, while the values of Frost and Brown are 0.122 Å, 0.067 Å and 0.128 Å smaller, respectively, for the three lines than the wave-lengths in stars. The two laboratory determinations differ by 0.11 Å 0.05 Å and 0.11 Å, respectively, for the three lines, which is equal to an average systematic difference of 0.090 Å. Measures by Frost of another plate, taken by Mr. Fulcher, of the

silicon spark in air gave the wave-length of λ 4,567 ". . . quite a little larger than on the plates taken with the observatory grating." This latter measure was not given, but it is in the direction of the value for the line by Exner and Haschek. Frost (*Aph. Jour.*, 1910) recognized the fact that the use of his laboratory determinations of the wave-lengths did not increase the accordance, in stellar spectra, of the velocities from the separate silicon lines.

The large systematic differences in the laboratory determinations would indicate that the effective wave-lengths of these lines may be influenced, in some way at present unknown, by the conditions of the experiment. As the lines are generally diffuse and are sensitive to the atmosphere surrounding the spark, it seems likely that differences in the electrical conditions of the spark or in the surrounding atmosphere produce an unsymmetrical widening of the lines.

Further laboratory investigation of these lines, under a variety of different conditions, is of great importance in the discussion of fundamental problems in astrophysics.

On Fundamental Systems of Wave-lengths in Stellar Spectra, and especially for the B Type Stars: S. Albrecht. (Read by Mr. Parker.)

The object of this note is to point out a clew to the elimination, in part at least, of systematic errors in the wave-lengths of the B type stars.

In the stellar spectral types A to M a considerable number of the spectrum lines in two or more neighboring main divisions of the spectral classification have a common origin. This makes possible a comparison of the wave-lengths in any one type with the wave-lengths or system of wave-lengths in any other type, from types A to M, both inclusive. In consecutive spectral types the systems of wave-lengths can be compared with comparative ease. In the B types, however, the lines are, with a few exceptions, of entirely different origin from the lines of even the A type, and it is only by means of the few lines which the B and A types have in common that the system of wave-lengths in the B type can be connected with the systems of wave-lengths in types A to M.

A connection with each other of the systems of wave-lengths in the different spectral types is highly desirable in the solution of several problems, the more important of which are perhaps: (*a*) the classification of stellar spectral types; (*b*) the elimination from the system of wave-lengths for each type of shifts, other than those due to radial velocity, which are systematic for the entire system of lines, or for groups of lines in each type, and which may be due to such effects as "pressure" or to other causes. The shifts which are shared by all lines are at present included in the radial velocities of the stars.

One of the best lines which is at present available for this purpose is H-gamma. The wave-length in the A type was found to be 4,340.655, and it diminishes progressively, slowly from types A to G and more rapidly from types K to M. If we make a plot with wave-lengths as ordinates and spectral types as abscissæ, a smooth curve can be drawn through the points in the plot from types A to M. If this curve were extended to the B type, it would indicate a wave-length for that type of 4,340.657. The wave-length actually found for the line in the B types is 4,340.627.

As pointed out above this difference for the B type, relatively to other spectral types, is at present to be taken as merely an indication of a method of approach for the solution of this problem. The final solution will have to be based upon a greater number of lines, extending over a longer portion of the spectrum. For a proper distribution to each spectral type, of relative differences which may be found in the different types, it will be absolutely essential to have an accurate knowledge of the behavior of spectrum lines under various different conditions.

In conclusion I wish to refer briefly to the importance which the solution of this question has in connection with our conception of the structure of the sidereal universe. If the results found for H-gamma should be confirmed by a more extensive investigation, such systematic differences in the radial velocities of stars as a function of the spectral type, as were found, I believe, by Kapteyn, Frost and Campbell, may find a simple explanation.

Photographic Determination of the Position of the Moon: Henry Norris Russell. (Read in connection with the Symposium on Photographic Astrometry.)

The photographs discussed below were taken at Harvard by Mr. King, and, by the kindness of Professor Pickering, were sent to the writer for discussion. They were measured and reduced at Princeton by Professor A. H. Joy, of the Syrean Protestant College, Beirut, and the writer, according to plans prepared by the latter. An account of the results will soon appear in the *Harvard Annals.*

To secure comparable images, the exposures to the moon must be less than a thousandth of those on the neighboring stars; and, except during this short exposure the objective must be completely shielded from the moon's rays to avoid fogging by diffusely reflected light. This was accomplished by placing a disk, some distance in front of the telescope, which shades the objective from the moon, but is not so large as to cut off much of the light from the surrounding stars. This disk may be turned edgewise for a short exposure on the moon, the exact time of which is recorded chronographically.

The instrument employed was the Metcalf telescope of sixteen inches aperture and eighty-seven inches focal length, stopped down to $3\frac{1}{2}$ inches aperture, with a disk five inches in diameter carried on a pole nine feet long attached to the telescope tube. Exposures of ten minutes on the stars and of 0.2 to 0.4 second on the moon, gave very satisfactory plates.

A standard réseau was photographed on each plate. The rectangular coordinates of the stars chosen for reference points were measured with respect to this system, and also those of ten or more points on the moon's illuminated limb (most of these being the intersections of the limb and réseau lines). After allowing for the slight distortion of the moon's apparent disk by refraction, the circle which passed as close as possible to the measured points on the limb was determined by least-squares, and its center assumed to coincide with that of the moon. The determination of the right ascension and declination corresponding to this point on the plate and the comparison with the tabular places of the American Ephemeris, were made in the usual way.

The probable error with which the coordinates of a star relative to its neighbors are determined from a single plate is $\pm 0''.25$. The absolute positions of the same stars, given in the catalogues consulted, appear to have probable errors of about $\pm 0''.4$ in each coordinate. The measures of the moon's limb are almost as accurate as those of the star-images; but the actual irregularities of the surface raise the probable error of position of one measured point (determined by means of its departure from the mean circle of the limb) to $\pm 0''.47$.

More dangerous than any of these errors is that arising from imperfect guiding. If the telescope is not directed towards exactly the same point in the heavens during the short exposure on the moon as, on the average, it is during the long exposure on the stars, errors will result which with a poor mounting might be very serious.

To investigate such errors, special plates were taken, on which bright stars were photographed in exactly the same way as the moon. These showed that the combined effects of errors of guiding and measurement is equivalent to a probable error of $\pm 0^s.031$ in R.A. and $\pm 0''.29$ in declination.

Combining all these results it appears that the known errors of observation will account for probable errors in the deduced places of the moon of $\pm 0^s.044$ in R.A. and $\pm 0''.40$ in declination.

Eleven plates have so far been discussed. The agreement of pairs taken on the same night is satisfactory. Comparison of the results of observations on different nights is complicated by the fact that the errors of the moon's tabular place are now large and variable. Through the courtesy of the Astronomer Royal, Professor Dyson, the results of the Greenwich meridian observations of the moon are available for comparison. The Greenwich and Harvard results agree excellently *inter se*, showing that in December, 1910 (during which month most of the plates now discussed were taken), the moon was ahead of her tabular position by an amount varying from $10''.7$ on December 9 to $4''.8$ on December 22, and at the same time $0''.6$, on the average, south of the tabular place. Representing this by an empirical curve, it is found that the outstanding probable errors of one observation at Greenwich are $\pm 0^s.048$ R.A. and $\pm 0''.57$ in declination, while those of the result of one plate are $\pm 0^s.043$ and $\pm 0''.55$.

The photographic method, therefore, appears to give results, on its first trial, somewhat superior in accuracy to those of meridian observations of the first class. It also appears, upon comparison of the observed and predicted probable errors of observation, that the greater part of the error of the photographic results arises from definitely known sources of error. There is little doubt that these can be considerably diminished by appropriate methods.

The photographic method has also the two great advantages that its errors are for the most part different in origin from those of meridian observations, and hence independent of them, and that it is available over a wide range of hour angles. It seems, therefore, likely to prove of great value in the attempt to improve our knowledge of the moon's motion.

Many more plates have already been taken at

Harvard, and it is hoped that arrangements for their regular measurement will soon be completed.

Note on the Ellicott Astronomical Instruments: A. E. Douglass.

These five instruments are now on permanent exhibition in the U. S. National Museum at Washington. They were partly made by Ellicott between 1780 and 1790 and were all used by him between that time and 1820. The zenith sector, six feet in focus, is suspended by its objective end. The eye end carries an arc, divided to degrees, which passes beneath a plumb line. The fractions of degrees are read by a micrometer. This is the type of instrument by which Bradley discovered aberration and nutation and with which the flattening of the earth's figure was first determined. This telescope itself was made by the Rittenhouse brothers in Philadelphia before 1784 and is a copy of the instrument used in locating Mason and Dixon's line. This instrument was used in locating the point where the boundary between the United States and Canada touches the St. Lawrence River. Bradley's original sector with its iron tube and mounting is now in the Royal Observatory, Greenwich. The small zenith sector, 20 inches in length, was used as a substitute for the larger in much boundary work.

The "transit and equal altitude" instrument was used in laying out the boundaries and avenues of the city of Washington, and many state boundaries. It is the type used in much surveying work in the eighteenth century. Instruments of this type may also be seen in the American Philosophical Society at Philadelphia, at Harvard University and in the Museum of the Buffalo Historical Society.

The quadrant is the oldest type of measuring telescope and is likely to be the oldest of this collection. A similar instrument of larger size is at Harvard University. There are many in the European Science Museums.

The four-foot telescope was made by W. and S. Jones, of London. It was used for longitude work by observations of Jupiter's satellites.

The metal work of these instruments is entirely of brass and, except for two of the smaller lenses, all are in excellent condition.

Report of the Committee on Photographic Astrometry: F. Schlesinger, chairman.

The report of this committee took the form of a symposium. The chairman outlined briefly what had been done previously on the determination of star places by photography. The experiments of Pickering, Hagen, Hirayama, Trümpler, Donner, Jacoby, Cookson, Ross and Pluvinel were briefly described. The chairman then presented the following resolutions, which were adopted at a meeting of the committee held in New York on April 23, 1911, when there were present Messrs. H. Jacoby, E. C. Pickering, H. N. Russell, F. Schlesinger, E. W. Brown and S. A. Mitchell, the last two by invitation:

RESOLUTIONS

The Committee on Photographic Astrometry of the Astronomical and Astrophysical Society of America is strongly of the opinion that photographic methods can be applied successfully to absolute as well as to differential determinations of star positions, thereby gaining the advantage of independent observations with instruments of entirely different characters. The committee recommends:

1. That the north and south polar points be determined by means of trails secured with a fixed telescope according to the method originally proposed by Pickering and developed by Jacoby.

2. That these polar points be connected with a number of regions on the equator and that the latter be connected among themselves by the methods proposed by Turner on pages 427 et seq., Vol. LXXI., *Monthly Notices of the Royal Astronomical Society.*

3. That the method proposed by Pickering (to be published soon in the *Harvard Circulars*) be used to determine the positions of stars to the twelfth magnitude in the immediate vicinity of the equator.

4. That the differential method proposed by Turner (page 422, Vol. LXXI., *Monthly Notices of the Royal Astronomical Society*) be employed to ascertain the positions of stars referred to the standard regions mentioned under 2.

The committee is further of the opinion that the degree of accuracy attainable by these methods can not be predicted with certainty, but can be found only by accurate trial.

The symposium then continued with the reading of papers (given above in abstract) by E. C. Pickering and H. N. Russell; and various aspects of the general problem were discussed by Messrs. C. L. Doolittle, Littell, Russell, Tucker, E. C. Pickering, Frisby and the chairman.

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